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Stability in health behavior patterns in middle adulthood: a 19-year follow-up study

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ABSTRACT

Objective: This study investigated subgroups of adults with particular health behavior patterns, their stability over 19 years, and the role of sociodemographic and personality characteristics in these.

Methods and Measures: Data on smoking, alcohol consumption, and physical activity were collected at ages 42, 50, and 61 in the Jyväskylä Longitudinal Study of Personality and Social Development (n=205–302). Latent class, latent transition, and logistic regression analyses were used.

Results: Four similar classes of health behaviors were identified at each age. A class named *low alcohol consumption (AC)–high physical activity (PA)* included individuals with the lowest levels of alcohol consumption and the highest levels of physical activity, and a class named *high AC–low PA* vice versa. Classes between these extremes of alcohol consumption and physical activity levels were *nonsmokers* with the lowest proportion of smokers, and *smokers* vice versa. Although transitions emerged, class memberships were relatively stable. Women, those who were married, held a degree, had higher occupational status, and certain personality traits at age 42 were more likely to belong continuously to healthier classes compared to a stable membership in *high AC–low PA*.

Conclusion: Health behaviors exist in patterns, are relatively stable across adulthood, and associated with sociodemographic and personality characteristics.

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Smoking; alcohol consumption; physical activity; latent transition analysis; longitudinal study

Introduction

Health behaviors such as smoking, heavy alcohol consumption, and low physical activity are among the major contributors to deaths and disability-adjusted life years (Murray et al., 2020). According to a global estimation, in 2019, 8.7 million deaths were attributable to tobacco use and 2.4 million deaths to alcohol use, while estimates

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for deaths accounted for low physical activity varied from almost 1 million (Murray et al., 2020) to over 3 million, the latter evaluated in 2010 (Lim et al., 2012). Health problems tend to accumulate in later life, and certain risk factors may become more harmful. For example, diseases together with current medications and natural age-related decline in tolerance increase the health risks caused by alcohol use (National Institute on Alcohol Abuse and Alcoholism (NIAAA), n.d.). However, multiple health outcomes in late adulthood, such as higher risks for mortality (Shaw & Agahi, 2012), non-communicable diseases (Lafortune et al., 2016), poor functional capacity (Sabia et al., 2009, 2014), disability (Artaud et al., 2016), and lower mental well-being (Avis et al., 2021), can already be predicted by unhealthy behaviors engaged in during middle adulthood, making it a pivotal phase of life to reflect and take actions over one's health.

Despite the scientific tradition of examining health behaviors one by one, behaviors co-occur within a person (Meader et al., 2016; Noble et al., 2015). Accordingly, it is important to examine their simultaneous occurrence since the role of a single health behavior in middle adulthood with, for example, mortality risk (Ding et al., 2015; Shaw & Agahi, 2012) and functional capacity (Sabia et al., 2009, 2014) depends on the other engaged behaviors. Specifically, the higher the number of unhealthy behaviors, the higher the risk of later adverse health outcomes (Sabia et al., 2009, 2014; Shaw & Agahi, 2012). The behaviors may also interact and modify one another's associations with health outcomes such that the joint risk is higher than the sum of individual risks (Ding et al., 2015; Shaw & Agahi, 2012). In addition to the co-occurrence, the length of an exposure to the behavior matters; the longer the exposure to unhealthy behaviors or trajectories toward unhealthy behaviors across middle adulthood, the higher the risk of poor functional capacity (Sabia et al., 2009, 2014) and disability (Artaud et al., 2016).

Studies utilizing latent class analysis (LCA) or latent profile analysis have identified typically three to five classes of health behaviors among middle-aged adults (Kim et al., 2020; Kontro et al., 2021; Mawditt et al., 2016; Min et al., 2022). They have suggested that healthy and unhealthy behaviors co-occur with respective behaviors, varying from classes characterized by multiple healthy behaviors (e.g. nonsmoking and engagement in greater physical activity) to classes of several unhealthy behaviors (e.g. smoking and heavy alcohol consumption). Between the extremes, they have also found intermediate classes characterized as relatively healthy behaviors, except for some behaviors (e.g. *healthy except alcohol* class) (Kim et al., 2020; Kontro et al., 2021; Mawditt et al., 2016; Min et al., 2022).

According to the longitudinal studies, the majority of individuals remain in the same health behavior class over time (Burgard et al., 2020; Mawditt et al., 2019; Wu et al., 2023). However, changes to both healthier and unhealthier behaviors have emerged, with the first ones being more common due to cessation of smoking (e.g. transitions from *moderate smokers* to *mainstream* class) (Mawditt et al., 2019) and drinking (e.g. from other profiles to *nondrinker* profile) (Burgard et al., 2020). These findings are in line with observational studies examining single behaviors in middle adulthood, which have reported decreasing trends in the prevalence of current smokers (Frank et al., 2004; Midlöv et al., 2014; Mulder et al., 1998; Tabuchi et al., 2017) and the mean level of alcohol consumption, particularly among heavy drinkers (Eigenbrodt

et al., 2001; Knott et al., 2018; Molander et al., 2010; Mulder et al., 1998). Meanwhile, trends for physical activity levels have varied between the studies (Artaud et al., 2016; Mulder et al., 1998; Yang et al., 2017).

Previous studies also suggest that classes of health behaviors are unequally distributed across the population (Kim et al., 2020; Mawditt et al., 2018; Min et al., 2022; Wu et al., 2023). Being older, woman, married, currently working, and having higher educational background and household income have repeatedly been associated with belonging to classes characterized by healthier behaviors (Kim et al., 2020; Min et al., 2022; Wu et al., 2023). In addition, a lower socioeconomic position in adulthood was associated with a higher probability of belonging to unhealthier classes (Mawditt et al., 2018). Alongside the research on sociodemographic characteristics, none of the previous person-centered studies have examined the role of personality traits although the traits based on the five-factor model have been associated with smoking (Hakulinen et al., 2015b; Kekäläinen et al., 2023), alcohol consumption (Hakulinen et al., 2015a; Kekäläinen et al., 2023), and physical activity levels (Karvonen et al., 2020; Kekäläinen et al., 2023; Wilson & Dishman, 2015). Among the traits describing individual differences in feeling, thinking, and behaving (McCrae & Costa, 2003, p. 25), conscientiousness and lower neuroticism were most consistently linked to healthier behaviors, while extraversion was associated with greater physical activity as well as with smoking and heavy alcohol consumption (Hakulinen et al., 2015a; 2015b; Karvonen et al., 2020; Kekäläinen et al., 2023; Wilson & Dishman, 2015).

Although there are a few studies examining the co-occurrence of multiple health behaviors among middle-aged adults (Kim et al., 2020; Kontro et al., 2021; Mawditt et al., 2016; Min et al., 2022), these are limited to examining only women (Min et al., 2022) or men (Kontro et al., 2021) or younger samples (Mawditt et al., 2016). Since previous population-based studies have followed their middle-aged participants for less than 10 years (Mawditt et al., 2019; Wu et al., 2023), long-term stability and the associations of sociodemographic and personality characteristics with it remain understudied. Consequently, advancing the understanding on how health behaviors co-occur among middle-aged populations and how stable these behavioral patterns are requires more cohort studies with longer follow-up designs and samples from different societal backgrounds.

The present study adds to existing research by utilizing 19-year longitudinal data from the Jyväskylä Longitudinal Study of Personality and Social Development (JYLS, Kokko et al., 2024; Pulkkinen, 2017) to complete the following aims: (1) identify data-driven subgroups of individuals who engage in particular health behavior patterns, (2) examine probabilities of individuals either staying in the class or transferring between classes from age 42 to 50 and age 50 to 61, and (3) investigate whether stable class memberships or transitions between classes are associated with several sociodemographic and personality characteristics. Based on previous studies in middle adulthood (Kim et al., 2020; Kontro et al., 2021; Mawditt et al., 2016; Min et al., 2022), it was hypothesized that three to five classes of health behaviors are identified and that healthier classes are associated with being a woman, married, and having higher educational and occupational status. Among the personality traits, higher conscientiousness and lower neuroticism were, in particular, expected to be associated with belonging to healthier classes. Finally, as previously suggested (Burgard et al., 2020;

Mawditt et al., 2019; Wu et al., 2023), class memberships were hypothesized to be stable, while some transitions, mainly toward healthier classes, may be observed.

Materials and methods

Study design and participants

Data of this study were drawn from the JYLS launched in 1968 (Pulkkinen, 2017), including its latest data collection, Transitions at Age 60: Individuals Navigating Across the Lifespan (TRAILS) (Kokko et al., 2024). The initial sample consisted of 369 participants who were recruited through random selection of 12 second-grade school classes in Jyväskylä, Central Finland (born 1959, 53% males, native Finns). The same participants have been followed in seven major data collection waves, which were conducted at baseline at age 8, and after that at ages 14, 27, 36, 42, 50 (Pulkkinen, 2017), and 61 (Kokko et al., 2024). Data used in the present study were collected in three waves, from middle adulthood to the beginning of late adulthood, that is, at ages 42 (2001), 50 (2009), and 61 (2020–2021). The number of individuals who participated was 285 (83% of the available sample) at age 42, 271 (84%) at age 50, and 206 (68%) at age 61. A total of 6 participants had died by age 42, 12 by age 50, and 28 by age 61. The remaining study sample over the years has represented both the initial sample and the same-age Finnish cohort in their sociodemographic characteristics (Kokko et al., 2024; Pulkkinen, 2017).

The approval of the procedures at ages 42 and 50 was obtained from the Ethical Committee of the Central Finland Health District (Nos: 42/2000 and 10E/2008, respectively) (Pulkkinen et al., 2003; Pulkkinen & Kokko, 2010), while at age 61, the Ethical Committee of the University of Jyväskylä gave the approval to collect the data (December 13, 2019) (Kokko et al., 2024). The adult-aged participants also confirmed their voluntary participation by signing a written informed consent (Kokko et al., 2024; Pulkkinen, 2017).

Measures

Data on health behaviors were collected using questionnaires. The analytical sample consisted of 205–302 participants who provided self-reported data on their smoking, alcohol consumption, and/or physical activity at age 42 ($n = 285$), 50 ($n = 268$), and/or 61 ($n = 206$). Among the 302 participants, 198 individuals provided data thrice, 61 individuals twice, and 43 individuals once (66%, 20%, and 14% of the analytical sample, respectively).

Health behaviors

Smoking was assessed at ages 42, 50, and 61. At age 42, the participants were asked, "*Do you smoke or have you ever smoked cigarettes?*," with response options ranging from "0 = *I have never been a regular smoker*" to "5 = *I use tobacco products daily*" (Kokkonen et al., 2002). At ages 50 and 61, the same question was answered on three response options: "1 = *I have never smoked*," "2 = *I have quitted smoking at age* ___," and

"3 = *I am currently smoking*." The current smoking status of the participants at each time point was categorized into two, namely, nonsmokers, and smokers.

Alcohol consumption was evaluated at ages 42, 50, and 61 with multiple questions (Pitkänen et al., 2005). The participants were asked, "*How much alcohol do you take at one time? If you have quit, please refer to the situation before you had quit. Circle the most appropriate frequency option on each line.*" One portion of alcohol was defined as a bottle of beer, cider, or long drink (33 cl, 4.5%), a glass of table wine (12 cl), a glass of strong wine (8 cl), or a shot of spirits (4 cl). Consumption was reported on a quantity-frequency table including seven response options for quantity, ranging from "1 = *one drink or less*" to "7 = *20 drinks or more*" at the y-axis and another seven response options for frequency, ranging from "1 = *not at all*" to "7 = *6–7 times a week*" at the x-axis (Pitkänen et al., 2005). Following the procedures by Pitkänen et al. (2005), alcohol consumption was calculated by multiplying the reported quantity of alcohol at each row (12 g alc./portion) by the number of drinking days per year (1 = *not at all*: 0; 2 = *twice a year*: 2; 3 = *once every 2 months*: 6; 4 = *1.5 times a month*: 18; 5 = *once a week*: 52; 6 = *3.5 times a* week: 182; and 7 = *6.5 times a week*: 338). A sum of the items of the entire table represented the annual alcohol consumption, which was further divided based on the distribution into an eight-point scale of 0 = 0 g, 1 = 1–100 g, 2 = 101–500 g, 3 = 501–2000 g, 4 = 2001–4500 g, 5 = 4501–7000 g, 6 = 7001–10000 g, and 7 ≥ 10001 g.

Since the question on alcohol consumption did not consider current nondrinkers, those who reported in another question (i.e. *"Do you use alcohol?"*) that they had never drank or that they had quit drinking were coded as 0. To obtain nondrinker status, a participant had to have quit drinking at least a year before the data collection, owing to the tendency of heavy drinkers to have multiple short-term attempts to quit (Pitkänen et al., 2005).

Physical activity was measured at ages 42, 50, and 61 with a question concerning the frequency of leisure-time physical activity (Karvonen et al., 2020; Kekäläinen et al., 2023). The participants were asked, "*How often do you exercise (including incidental exercise) or pursue sports in your leisure time?"* The question was self-rated on a seven-point scale including "1 = *never*," "2 = *less than once a month*," "3 = *1–2 times a month*," "4 = *once a week*," "5 = *2–3 times a week*," "6 = *4–5 times a week*," and *"7 = practically every day."*

Covariates

Binary measures of sociodemographic characteristics, namely, gender (0 = men vs. 1 = women), marital status (0 = single, divorced, widowed vs. 1 = married), educational status (0 = vocational courses or less vs. 1 = a degree: vocational school, vocational college, polytechnic, university), and occupational status (0 = blue-collar workers vs. 1 = lower white-collar workers, upper white-collar workers) were based on information collected at age 42, except for gender, which was documented at the beginning of the longitudinal study.

Personality traits at age 42 were assessed using a shortened 60-item version of an authorized adaptation of the NEO Personality Inventory (Costa & McCrae, 1985; Pulver

et al., 1995). There were 12 items measuring each of the five traits: neuroticism, extraversion, openness, conscientiousness, and agreeableness. Participants rated the items presented on a randomly generated order on a 5-point Likert-type scale, with 1 indicating strong disagreement and 5 indicating strong agreement. Cronbach's alphas suggested good internal consistency of the scales ranging from 0.78 to 0.86 (Pulkkinen et al., 2012).

Statistical analyses

Descriptive statistics were computed for the health behaviors, sociodemographic and personality characteristics, and longitudinal change in the health behavior variables was tested with paired samples proportions and t-tests using IBM SPSS Statistics version 28. A longitudinal extension of LCA, namely, latent transition analysis (LTA), was conducted on Mplus version 8.8 (Muthén & Muthén, 2017) utilizing the step-by-step frameworks based on Nylund (2007) and Ryoo et al. (2018). Steps of the model building included (0) exploring cross-sectional data on health behaviors at ages 42, 50, and 61 using LCA; (1) testing longitudinal measurement invariance (MI) using LTA; (2) defining classes of health behaviors; (3) evaluating transition probability invariance; (4) defining stability in the memberships of the classes of health behaviors; and (5) assessing sociodemographic and personality characteristics as predictors of stable class memberships and transitions between classes. The results of steps 0, 1, and 3 are described in the Supplementary material. In the LCA and LTA models, starting values were set at 500 with 20 best solutions to identify the model with the highest maximum likelihood solution.

In step 0, LCA was performed separately for each time point to identify the optimal number of unobservable subgroups of individuals with similar values on the observed health behaviors. Different numbers of classes were specified, starting from a one-solution model and increasing the number of classes until six. The optimal number of classes was selected based on the recommended goodness-of-fit statistics: log likelihood value (LogL), Bayesian information criterion (BIC), sample-size adjusted BIC (SABIC), Akaike information criterion (AIC), entropy, the adjusted Lo-Mendell-Rubin likelihood ratio test (LMR), Bootstrapped likelihood ratio test (BLRT), and interpretability of the classes (Bauer, 2022; Nylund, 2007). Moreover, small classes of less than 5% and 1% of the sample were documented. Decreasing BIC, SABIC, and AIC values and increasing LogL values and entropy indicated improved model fit (Bauer, 2022; Nylund, 2007). LMR and BLRT tests evaluated the statistically significant improvement ($p < 0.05$) in fit between the k–1 and k-class models (Nylund, 2007).

LTA was performed to identify characteristics of the discrete latent classes and probabilities of individuals either staying in the class or transferring between classes (Figure 1). In step 1, the investigation of longitudinal MI included a comparison of BIC and AIC values and the use of the Satorra-Bentler chi-square difference test (MLR estimator), which assesses differences in LogL values between invariance (equal item means and probabilities) and noninvariance (freely estimated item means and probabilities) models (Nylund, 2007; Nylund-Gibson et al., 2022;

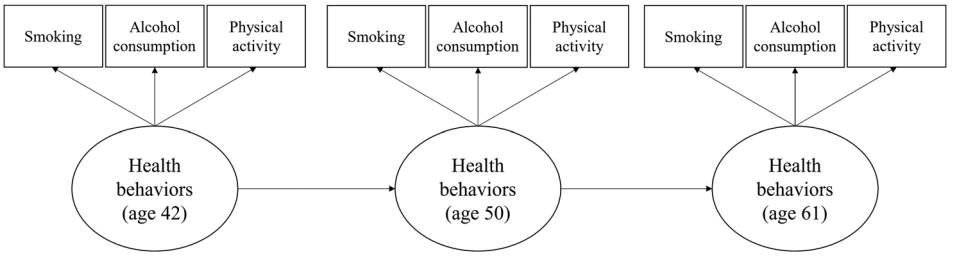

Figure 1. Model diagram for the LTA based on longitudinal data with multiple observed indicators.

Ryoo et al., 2018). In step 2, the classes were ordered to facilitate the interpretation of the data, and characteristics of the classes were described as item probabilities for categorical variables and means for continuous variables. For descriptive purposes, pairwise test for mean and probability differences between latent classes were tested using the new variable definition (the feature implemented in Mplus).

The central parameters of LTA are transition probabilities that estimate the movement of individuals among the latent classes based on multinomial logistic regression (Nylund, 2007; Nylund-Gibson et al., 2022). In step 3, since transition probabilities can be constrained the same between multiple follow-up periods (Nylund, 2007), the models with constrained transition probabilities and free transition probabilities were compared. In step 4, the transition probabilities were described. In step 5, to test ability of sociodemographic and personality characteristics in predicting (1) stable class memberships and (2) transitions between classes, one latent categorical variable with 64 classes was used. Based on the previously identified model including one categorical variable with four latent classes at each time point (step 2), appropriate restrictions to the mean values and thresholds of the classes were set to the model with one latent categorical variable with 64 classes to achieve the equality between the two models. This one latent categorical variable model allowed the use of covariates to compare a certain pair of latent classes corresponding to two cells in the transition probability matrix.

Although there are missing data, LTA estimates a probability to belong to each class for each participant at each time point. For sensitivity purposes, those who participated in at least one measurement but died during the follow-up period ($n = 19$) were excluded in the supplementary analysis (Supplementary material).

Results

Descriptive statistics on health behaviors and sociodemographic and personality characteristics are shown in Table 1. The mean-level alcohol consumption remained similar at ages 42 and 50 but was statistically significantly lower at age 61 compared to ages 42 and 50. Physical activity was statistically significantly lower at age 42 than at 50 and 61 and similar at 50 and 61. The percentage of smokers was statistically significantly lower at both follow-up measurements.

Table 1. Descriptive statistics based on cross-sectional data.

	Age 42			Age 50			Age 61		
	n	M/n	SD/%	n	M/n	SD/%	n	M/n	SD/%
Health behaviors									
Alcohol consumption (0–7)	280	3.81	1.79	254	3.77	2.01	205	3.45[ab]	2.04
Physical activity (1–7)	277	4.86	1.50	261	5.20[a]	1.55	206	5.32[a]	1.43
Smoking	284			265			206		
Nonsmoker		163	57.4		190[a]	71.7		169[ab]	82.0
Smoker		121	42.6		75[a]	28.3		37[ab]	18.0
Sociodemographic characteristics									
Gender	302								
Women		138	45.7						
Men		164	54.3						
Marital status	279								
Married		168	60.2						
Single, divorced or widowed		111	39.8						
Educational status	284								
A degree		226	79.6						
Vocational courses or less		58	20.4						
Occupational status	283								
White-collar worker		185	65.4						
Blue-collar worker		98	34.6						
Personality traits	233								
Neuroticism (1–5)		2.37	0.68						
Extraversion (1–5)		3.30	0.58						
Openness (1–5)		3.32	0.59						
Conscientiousness (1–5)		3.70	0.53						
Agreeableness (1–5)		3.63	0.52						

Note. Based on the maximum number of participants at each time point. n: number of participants, M: mean, : standard deviation.
[a]Statistically significant difference to age 42.
[b]Statistically significant difference to age 50.

Classes of health behaviors

A four-solution model with non-equal indicator means and item probabilities was chosen based on the model-fit criteria (Tables S1–S2, Supplementary material). Steps 0 and 1 of the model building and the model-fit indices for all LCA and LTA models are described in more detail in the Supplementary material.

The data-driven classes of health behaviors were named as follows: *low alcohol consumption (AC)—high physical activity (PA)* (C1), *nonsmokers* (C2), *smokers* (C3), and *high AC—low PA* (C4) (Table 2). The same names were used for similar classes across the three time points despite small differences in the indicator means and item probabilities. *Low AC—high PA* (14%, 16%, and 19% of the analytical sample at each time point, respectively) included individuals with the lowest levels of alcohol consumption, the highest levels of physical activity, and only a small minority of smokers. *High AC—low PA* (23%, 24%, and 23%) included individuals with the highest levels of alcohol consumption, the lowest levels of physical activity, and a relatively high proportion of smokers. Classes between the aforementioned extremes of alcohol consumption and physical activity levels were *nonsmokers* (38%, 44%, and 41%), which included the lowest proportion of smokers, and *smokers* (26%, 16%, and 17%), which included the highest proportion of smokers of all classes. Most participants were assigned into *nonsmokers* at each age. There was a significant variability in the proportion of smokers within the *smokers* class between the time points.

Table 2. Prevalence and description of latent classes ($n = 302$).

		Low AC–high PA (C1)	Nonsmokers (C2)	Smokers (C3)	High AC–low PA (C4)
Prevalence (%)					
	42	13.5	37.6	25.7	23.1
	50	15.6	44.4	16.3	23.6
	61	18.8	41.0	16.9	23.3
Smoking (p)					
Nonsmoker	42	0.86 (C2, C3, C4)	1.00 (C1, C3, C4)	0.00 (C1, C2, C4)	0.35 (C1, C2, C3)
	50	0.83 (C2, C3, C4)	0.99 (C1, C3, C4)	0.14 (C1, C2)	0.48 (C1, C2)
	61	0.94 (C2, C3, C4)	1.00 (C1, C3, C4)	0.42 (C1, C2)	0.61 (C1, C2)
Smoker	42	0.14 (C2, C3, C4)	0.00 (C1, C3, C4)	1.00 (C1, C2, C4)	0.65 (C1, C2, C3)
	50	0.17 (C2, C3, C4)	0.01 (C1, C3, C4)	0.86 (C1, C2)	0.52 (C1, C2)
	61	0.06 (C2, C3, C4)	0.00 (C1, C3, C4)	0.58 (C1, C2)	0.39 (C1, C2)
Alcohol consumption (M) (0–7)					
	42	1.14 (C2, C3, C4)	3.35 (C1, C3, C4)	3.82 (C1, C2, C4)	6.25 (C1, C2, C3)
	50	0.59 (C2, C3, C4)	3.53 (C1, C4)	3.61 (C1, C4)	6.63 (C1, C2, C3)
	61	0.67 (C2, C3, C4)	3.10 (C1, C4)	3.73 (C1, C4)	6.42 (C1, C2, C3)
Physical activity (M) (1–7)					
	42	5.69 (C2, C3, C4)	5.04 (C1, C4)	4.62 (C1)	4.33 (C1, C2)
	50	5.76 (C3, C4)	5.51 (C4)	4.77 (C1)	4.46 (C1, C2)
	61	5.83 (C3, C4)	5.52	4.59 (C1)	4.95 (C1)

Note. The latent classes, in parentheses, indicate that there is a statistically significant difference (p-value < 0.05) between the classes. p = proportion, M = mean.

Stability in the memberships of classes of health behaviors

The model with free transition probabilities was chosen (Step 3, Supplementary material). The transition matrix indicated that the memberships of the *low AC—high PA* and *nonsmokers* classes tended to be most stable from age 42 to 50 and age 50 to 61 (Table 3). Individuals assigned into *smokers* transitioned most often, either into the *nonsmokers* or *high AC—low PA* class. Members of the *high AC—low PA* class most likely stayed within the class or transitioned into *nonsmokers* or *smokers*. In general, the probabilities of staying in the baseline class were higher at ages 50 to 61 than at 42 to 50.

Table 3. Transition matrix with transition probability estimates (τ) between ages 42 and 50 and between 50 and 61 ($n = 302$).

	τ estimate from age 42 to 50				τ estimate from age 50 to 61			
	C1	C2	C3	C4	C1	C2	C3	C4
Low AC–high PA (C1)	**0.892**	0.108	0.000	0.000	**0.963**	0.037	0.000	0.000
Nonsmokers (C2)	0.021	**0.884**	0.024	0.071	0.044	**0.906**	0.000	0.050
Smokers (C3)	0.039	0.251	**0.520**	0.190	0.074	0.000	**0.696**	0.230
High AC–low PA (C4)	0.075	0.142	0.090	**0.693**	0.025	0.008	0.233	**0.733**

The four classes across the three time points led into 64 possible transition paths. The most common path was to belong to *nonsmokers* across the follow-up (29.4%) followed by a stable membership in the *high AC—low PA* (14.0%), *low AC—high PA* (11.4%), and *smokers* (9.6%) classes. The fifth highest path in terms of frequency included those who were assigned to *smokers* at age 42 but transitioned to *nonsmokers* by age 50 and stayed there until the age of 61 (6.4%).

Sociodemographic and personality characteristics as predictors of stable class memberships and transitions between classes

Covariate tests on sociodemographic characteristics predicting stable class memberships indicated that women and those who were married and held a degree at age 42 were more likely to belong continuously to the *low AC—high PA* or *nonsmokers* class compared to a stable membership in *high AC—low PA* (Table 4). Women were also more likely be assigned to the *smokers* than the *high AC—low PA* class. In addition to gender and marital and educational statuses, the proportion of white-collar workers at age 42 was higher among those who belonged continuously to the *nonsmokers* class compared to a stable membership in *high AC—low PA*.

Table 4. Sociodemographic characteristics predicting stable class memberships.

	OR	SE	95% CI
Women (ref. men)			
High AC–low PA	1		
Low AC–high PA	**6.78**	**2.81**	**[3.01–15.28]**
Nonsmokers	**10.74**	**3.25**	**[5.94–19.42]**
Smokers	**8.63**	**5.13**	**[2.70–27.66]**
Married (ref. single, divorced, widowed)			
High AC–low PA	1		
Low AC–high PA	**2.89**	**1.32**	**[1.18–7.07]**
Nonsmokers	**2.16**	**0.64**	**[1.21–3.87]**
Smokers	0.70	0.34	[0.27–1.81]
A degree (ref. vocational courses or less)			
High AC–low PA	1		
Low AC–high PA	**8.61**	**6.72**	**[1.86–39.78]**
Nonsmokers	**3.63**	**1.41**	**[1.69–7.79]**
Smokers	1.34	0.77	[0.43–4.15]
White-collar worker (ref. blue-collar worker)			
High AC–low PA	1		
Low AC–high PA	1.96	0.86	[0.83–4.64]
Nonsmokers	**6.17**	**2.39**	**[2.89–13.19]**
Smokers	1.26	0.65	[0.46–3.46]

Note. Sociodemographic characteristics analyzed in separate logistic regression models. OR = odds ratio, SE = standard error, 95% CI = 95% confidence interval. Statistically significant results (CI does not include 1) bolded.

Among the personality traits, those who scored lower in extraversion and higher in openness and conscientiousness were more likely to belong to the *low AC—high PA* or *nonsmokers* class at each age compared to a stable membership in *high AC—low PA* (Table 5). Additionally, lower neuroticism and higher agreeableness increased the likelihood of individuals belonging continuously to *nonsmokers* compared to *high AC—low PA* class.

It was further examined if those who transitioned between classes (movers > 14%) differed from those who stayed within the class, separately at follow-up periods from age 42 to 50 and age 50 to 61 (Table 6). Those who transitioned from the *smokers* to *high AC—low PA* class between ages 42 and 50 were less often women and held less often a degree at age 42 compared to those who stayed within the baseline class.

Analyses on personality traits suggested that those who moved from *smokers* to *high AC—low PA* class during the latter follow-up period from age 50 to 61 scored lower in openness and conscientiousness at age 42 compared to those who stayed within the *smokers* class (Table 7).

Table 5. Personality characteristics predicting stable class memberships.

	OR	SE	95% CI
Neuroticism (1–5)			
High AC–low PA	1		
Low AC–high PA	1.16	0.54	[0.46–2.89]
Nonsmokers	**0.55**	**0.14**	**[0.34–0.90]**
Smokers	1.67	1.05	[0.49–5.71]
Extraversion (1–5)			
High AC–low PA	1		
Low AC–high PA	**0.33**	**0.17**	**[0.12–0.92]**
Nonsmokers	**0.24**	**0.08**	**[0.12–0.46]**
Smokers	0.63	0.40	[0.19–2.17]
Openness (1–5)			
High AC–low PA	1		
Low AC–high PA	**2.87**	**1.01**	**[1.44–5.73]**
Nonsmokers	**2.15**	**0.61**	**[1.22–3.76]**
Smokers	2.28	1.55	[0.60–8.65]
Conscientiousness (1–5)			
High AC–low PA	1		
Low AC–high PA	**4.46**	**1.71**	**[2.10–9.46]**
Nonsmokers	**2.40**	**0.78**	**[1.27–4.53]**
Smokers	1.24	0.81	[0.34–4.50]
Agreeableness (1–5)			
High AC–low PA	1		
Low AC–high PA	2.26	0.98	[0.96–5.30]
Nonsmokers	**3.15**	**0.97**	**[1.72–5.76]**
Smokers	2.43	2.31	[0.38–15.62]

Note. Personality characteristics analyzed in same logistic regression models. OR = odds ratio, SE = standard error, 95% CI = 95% confidence interval. Statistically significant results (CI does not include 1) bolded.

Table 6. Sociodemographic characteristics predicting change between classes.

	42–50			50–61		
	OR	SE	95% CI	OR	SE	95% CI
Women (ref. men)						
Smokers → Smokers	1			1		
Smokers → Nonsmokers	0.75	0.50	[0.20–2.76]	–	–	–
Smokers → High AC–low PA	**0.04**	**0.06**	**[0.00–0.81]**	0.37	0.32	[0.07–2.07]
High AC–low PA → High AC–low PA						
High AC–low PA → Nonsmokers	*	*	*	–	–	–
High AC–low PA → Smokers	–	–	–	*	*	*
Married (ref. single, divorced, widowed)						
Smokers → Smokers	1			1		
Smokers → Nonsmokers	0.50	0.35	[0.13–1.99]	–	–	–
Smokers → High AC–low PA	1.64	1.26	[0.36–7.38]	0.50	0.43	[0.09–2.70]
High AC–low PA → High AC–low PA	1			1		
High AC–low PA → Nonsmokers	0.66	0.56	[0.12–3.45]	–	–	–
High AC–low PA → Smokers	–	–	–	1.52	1.77	[0.16–14.92]
A degree (ref. vocational courses or less)						
Smokers → Smokers	1					
Smokers → Nonsmokers	0.38	0.24	[0.11–1.32]	–	–	–
Smokers → High AC–low PA	**0.15**	**0.10**	**[0.04–0.55]**	*	*	*
High AC–low PA → High AC–low PA	1			1		
High AC–low PA → Nonsmokers	0.87	0.76	[0.16–4.81]	–	–	–
High AC–low PA → Smokers	–	–	–	1.42	1.27	[0.25–8.23]
White-collar worker (ref. blue-collar worker)						
Smokers → Smokers	1			1		
Smokers → Nonsmokers	2.41	1.97	[0.49–12.00]	–	–	–
Smokers → High AC–low PA	0.34	0.26	[0.08–1.54]	0.91	0.91	[0.13–6.43]
High AC–low PA → High AC–low PA	1			1		
High AC–low PA → Nonsmokers	0.70	0.59	[0.14–3.62]	–	–	–
High AC–low PA → Smokers	–	–	–	0.53	0.37	[0.13–2.07]

Note. Sociodemographic characteristics analyzed in separate logistic regression models. OR = odds ratio, SE = standard error, 95% CI = 95 % confidence interval. Statistically significant results (CI does not include 1) bolded.
*Cells with 0 cases identified. 0 cases were replaced with 1 and chi-square tests performed on SPSS statistical software indicated statistically nonsignificant results.

Table 7. Personality characteristics predicting change between classes.

	42–50			50–61		
	OR	SE	95% CI	OR	SE	95% CI
Neuroticism (1–5)						
Smokers → Smokers	1			1		
Smokers → Nonsmokers	0.49	0.38	[0.11–2.22]	–	–	–
Smokers → High AC–low PA	0.98	0.64	[0.28–3.51]	1.49	1.02	[0.39–5.72]
High AC–low PA → High AC–low PA						
High AC–low PA → Nonsmokers	0.27	0.24	[0.05–1.53]	–	–	–
High AC–low PA → Smokers	–	–	–	0.71	0.42	[0.23–2.25]
Extraversion (1–5)						
Smokers → Smokers	1			1		
Smokers → Nonsmokers	0.76	0.47	[0.23–2.54]	–	–	–
Smokers → High AC–low PA	1.65	0.92	[0.55–4.93]	1.53	1.61	[0.19–12.04]
High AC–low PA → High AC–low PA	1			1		
High AC–low PA → Nonsmokers	0.56	0.38	[0.15–2.13]	–	–	–
High AC–low PA → Smokers	–	–	–	0.60	0.37	[0.18–2.03]
Openness (1–5)						
Smokers → Smokers	1			1		
Smokers → Nonsmokers	0.43	0.39	[0.07–2.51]	–	–	–
Smokers → High AC–low PA	0.83	0.76	[0.14–4.95]	**0.12**	**0.10**	**[0.02–0.60]**
High AC–low PA → High AC–low PA	1			1		
High AC–low PA → Nonsmokers	0.40	0.26	[0.11–1.46]	–	–	–
High AC–low PA → Smokers	–	–	–	0.64	0.38	[0.20–2.07]
Conscientiousness (1–5)						
Smokers → Smokers	1			1		
Smokers → Nonsmokers	0.85	0.90	[0.11–6.79]	–	–	–
Smokers → High AC–low PA	0.83	0.51	[0.25–2.78]	**0.15**	**0.13**	**[0.03–0.83]**
High AC–low PA → High AC–low PA	1			1		
High AC–low PA → Nonsmokers	0.42	0.46	[0.05–3.50]	–	–	–
High AC–low PA → Smokers	–	–	–	1.94	0.74	[0.91–4.11]
Agreeableness (1–5)						
Smokers → Smokers	1			1		
Smokers → Nonsmokers	1.47	1.04	[0.37–5.86]	–	–	–
Smokers → High AC–low PA	0.65	0.40	[0.20–2.14]	2.16	3.53	[0.09–53.26]
High AC–low PA → High AC–low PA	1			1		
High AC–low PA → Nonsmokers	1.10	0.85	[0.24–4.97]	–	–	–
High AC–low PA → Smokers	–	–	–	0.73	0.42	[0.24–2.26]

Note. Personality characteristics analyzed in same logistic regression models. OR = odds ratio, SE = standard error, 95% CI = 95 % confidence interval. Statistically significant results (CI does not include 1) bolded.

Sensitivity analyses

Sensitivity analyses (excluding those participants who attended at least one measurement but died during the follow-up) were similar to the main analysis and did not change the interpretation of the results (Tables S3–S5, Supplementary material, $n = 283$).

Discussion

The purpose of this study was to examine subgroups of individuals who engage in particular health behavior patterns, the stability in the memberships of the identified patterns from middle adulthood to the beginning of late adulthood, and the role of sociodemographic and personality characteristics in these among a representative sample of Finnish adults. In line with the results of previous studies finding three to five classes of health behaviors among middle-aged adults (Kim et al., 2020;

Kontro et al., 2021; Mawditt et al., 2016; Min et al., 2022), four health behavior patterns were identified in the current study. Many participants were assigned to healthier patterns, including the lowest proportion of smokers (*nonsmokers*: 38%, 44%, and 41% of the analytical sample at each time point, respectively) and the lowest levels of alcohol consumption and highest levels of physical activity (*low AC—high PA*: 14%, 16%, and 19%). Unhealthier patterns characterized by the highest proportion of smokers (*smokers*: 26%, 16%, and 17%) and the highest levels of alcohol consumption and lowest levels of physical activity (*high AC—low PA*: 23%, 24%, and 23%) were also observed. There was not a single class in which all three behaviors would be the most beneficial for health. Alcohol consumption was the most significant behavior distinguishing the discrete classes (means ranging from 0.59 to 6.63), followed by smoking (probabilities ranging from 0.00 to 1.00). Although physical activity did not differ as much between the classes and this study included a limited set of three health behaviors, in line with previous findings (Kim et al., 2020; Kontro et al., 2021; Mawditt et al., 2016; Min et al., 2022) both healthier (e.g. greater physical activity and lower alcohol consumption) and unhealthier behaviors (e.g. lower physical activity and greater alcohol consumption) co-occurred with respective behaviors.

The participants of the current study most likely remained in their baseline class over the 19 years, which suggests that health behaviors are relatively stable from middle adulthood to the beginning of late adulthood. These results are similar to other studies reporting relatively high stability in class memberships (Burgard et al., 2020; Mawditt et al., 2019; Wu et al., 2023). Furthermore, as found among British (Mawditt et al., 2019) and Japanese (Wu et al., 2023) cohorts, healthier patterns were more stable compared to unhealthier patterns. Several reasons may underlie these findings. First, high stability may be linked, also indirectly, to the individuals' relatively stable personality traits (Bogg & Roberts, 2004) and personal identities (Hagger et al., 2007), which are expressed in everyday behaviors. Normative mean-level changes in personality traits (Roberts et al., 2006), may, however, lead to behavior change. Second, high stability may reflect the findings that health behaviors develop early and track into adulthood (Paavola et al., 2004). However, health-related life goals become more important with aging (Martos et al., 2010), and increased incidence of diseases, related medication, and general health precaution (Britton and Bell, 2015; Molander et al., 2010) may influence aging adults reflecting and taking actions over their health. Third, while physiological dependence caused by smoking and alcohol consumption is thought to underlie the relatively high stability estimates (Benzies et al., 2008), unhealthier behaviors are more subject to change for being targets of health behavior change interventions and restrictive health policies. Societal circumstances may also explain the differences in the results of a study based on a Chinese population that reported unhealthier behaviors being more stable (Wu et al., 2023).

Transitions indicated general changes in health behaviors rather than changes in single behaviors, but the cessation of smoking and a decrease in alcohol consumption were likely to contribute to these transitions. The observed transitions from unhealthier classes are supported by previous studies using the same statistical approach (Burgard et al., 2020; Mawditt et al., 2019; Wu et al., 2023) and other longitudinal studies

reporting the cessation of smoking (Frank et al., 2004; Midlöv et al., 2014; Mulder et al., 1998; Tabuchi et al., 2017) and a decrease in alcohol consumption—particularly among heavy drinkers—in middle adulthood (Eigenbrodt et al., 2001; Knott et al., 2018; Molander et al., 2010; Mulder et al., 1998). In the current study, individuals transitioned most often from *smokers* to either the *nonsmokers* or *high AC—low PA* class, the latter suggesting an increase in alcohol consumption. The variability in smoking within *smokers* between time points probably contributed to the lack of movement to *nonsmokers* between ages 50 and 61. However, a reduction or increase in smoking could not be observed with the current binary variable. Transitions to the *high AC—low PA* pattern became more common in the latter follow-up period, highlighting the increased risks of staying in the *smokers* class at the age of 50. There were less transitions toward *smokers*, which may relate to the fact that smoking is typically started by the age of 25 (Reitsma et al., 2021). Thus, individuals rarely become smokers in middle adulthood.

Social circumstances may also shape and maintain the engaged health behaviors. In line with previous studies (Kim et al., 2020; Mawditt et al., 2018; Min et al., 2022; Wu et al., 2023), several sociodemographic characteristics, namely, being woman, married, more educated, and having a higher occupational status, were associated with a stable adherence to healthier patterns. Additionally, those who transitioned from *smokers* to the *high AC—low PA* pattern between ages 42 and 50 were more often men and had less often a degree, which raises concerns about the risk of increasing health inequalities between social groups. Mechanisms between social circumstances and health behavior patterns may relate to health literacy and the existing support from the individuals' social networks (Murakami et al., 2023).

Personality traits were also predictive of health behavior patterns. Individuals characterized as higher in openness, conscientiousness, and agreeableness and lower in neuroticism and extraversion were more likely to engage in healthier patterns. Additionally, those who transitioned from *smokers* to the *high AC—low PA* pattern between ages 50 and 61 exhibited lower openness and conscientiousness. Previous research utilizing the latent class approach in health behaviors has not examined the role of personality traits, but variable-centered studies (Hakulinen et al., 2015a; 2015b; Karvonen et al., 2020; Kekäläinen et al., 2023; Wilson & Dishman, 2015) are in agreement with the current findings. Interestingly, in contrast to the physical activity research, lower extraversion may be a resource factor that prevents the accumulation of unhealthy behaviors when examining health behavior patterns. Extraversion is lower and conscientiousness is higher in the *overcontrolled* personality profile than in the *undercontrolled* personality profile (Pulkkinen, 2017, p. 89). These personality profiles combining information on all traits may also be reflected in health behavior patterns.

The limitations of this study need to be noted. Measure of physical activity was not very informative in distinguishing classes from one another since the question concerned leisure-time exercise (including incidental exercise) of any intensity rather than moderate-to-vigorous physical activity. Thus, majority of the participants considered themselves to be relatively active. There was also a limited set of three health behaviors due to a lack of data on diet, which is consistently associated with morbidity

(Murray et al., 2020). However, it may be complicated to measure (Artaud et al., 2016). The included health behaviors were self-reported, causing a risk for social desirability and recall bias (Althubaiti, 2016). For example, reporting alcohol consumption may be perceived as sensitive and confounded by short attempts to quit, which, however, was considered in the study. In a longitudinal sense, this is a minor worry because the participants were compared to themselves. A follow-up period of 10 years is suitable for observing long-term changes in health behaviors but it does not reveal short-time changes. Despite the longitudinal design, the direction of the causal relationships between health behavior patterns and sociodemographic and personality characteristics could not be investigated by the used methods. Lastly, although the sample size of 302 participants was close to the lower boundary of sufficient sample size (Nylund-Gibson et al., 2022), the model-fit indices indicated good classification quality which is important for the reliability of the results. In covariate tests, the estimates were somewhat uncertain due to the relatively small sample sizes in the comparable classes.

The results of the current study represent the three health behaviors of a specific birth cohort in a specific period (2001–2021), which should be considered when generalizing the findings. The cohort of native Finns born in 1959 differs from later-born cohorts in aspects such as their homogeneous ethnic background, educational experiences (regarding health behaviors), and societal attitudes toward, for example, smoking, which have previously been more positive in Finland (Ministry of Social Affairs & Health, 2023). This study focused on a general population, and it is probable that the results do not fit people with risky alcohol use or substance use disorders. The distribution-based cut-off point for high alcohol consumption was set to 10 liters (≥10001 g) of pure alcohol per year based on what exceeds the high risk limit for females (12–16 portions per week) but not for males (22–24 portions per week) in Finland (Finnish Current Care Guidelines, 2018). Although people with alcohol dependency or multiple health problems are more likely to drop out from the study (Kokko et al., 2024), the analysis used the available data to estimate a probability to belong to each pattern for each participant at each time point. The sensitivity analyses (excluding those participants who attended at least one measurement but died during the follow-up) indicated similar results regarding the prevalence and characteristics of four health behavior patterns and the stability estimates related to them.

It is also difficult to differentiate whether the observed behavioral changes over time were caused by factors related to the particular age period or the emerging cohort effects caused by the changes in societal circumstances during the follow-up period. Similar to worldwide trends (Murray et al., 2020; Reitsma et al., 2021), smoking has decreased remarkably in Finland during the past decades (Tolonen et al., 2022). This is likely to be the result of government policies, such as restrictions in the Tobacco Act (Tobacco Act, 2016) (e.g. ban of marketing and smoking in common areas of the restaurants) and the increases in excise duty for tobacco products in the 2000s (Ministry of Social Affairs & Health, 2023). In Finland, the sale and production of alcohol are also regulated through Alko's (a limited liability company owned by the Finnish State) retail monopoly and the licensing system. Nonetheless, it is unclear whether changes made in the Alcohol Act (Alcohol Act, 2017) (e.g. rise

from 4.7% to 5.5% in the maximum strength of alcoholic beverages sold in retail stores) contributed to the increased consumption among those transitioning to the *high AC—low PA* pattern between ages 50 and 61. The study-specific differences in variables, samples, and analytic decisions related to LTA should also be noted when considering reproducibility of the results across studies. However, the sample is representative of the Finnish age cohort born in 1959, and the results are likely to represent the current situation in Finnish adults currently in their early 60s (Kokko et al., 2024; Pulkkinen, 2017).

The other strengths of this study include a longitudinal design for nearly 20 years with relatively small attrition over the years. Of the initial sample followed from 1968 onwards ($N = 369$), 302 participants provided information on their health behaviors in middle adulthood. Repeated measures of multiple health behaviors together with LTA allowed the assessment of the stability in class memberships. By conducting LTA, it was possible to investigate multiple health behaviors simultaneously (Nylund, 2007).

Conclusions

This study suggests that health behaviors exist in patterns and are relatively stable from middle adulthood to the beginning of late adulthood, though behavioral trends mainly in a healthier direction also emerge. The findings call for the promotion of healthy lifestyles, especially among those engaging simultaneously in smoking, heavy alcohol consumption, and low physical activity. As other researchers have discussed (Mawditt et al., 2016; Meader et al., 2016; Noble et al., 2015), interventions adopting a person-centered approach that tackles several unhealthy behaviors at the same time may be a more effective and cost-friendlier option. Results regarding the high stability further highlight the importance of supporting the development of a healthy lifestyle earlier at younger ages.

There seems to be a gradient in health behaviors across several sociodemographic characteristics, with women, married, more educated, and occupationally higher-positioned individuals engaging in healthier lifestyles. Since health behaviors are linked to social environments, interventions should also consider those resource factors that are modifiable, such as education, at an early phase. Furthermore, personality traits were also meaningful to health behavior patterns, with higher openness, conscientiousness, and agreeableness, and lower neuroticism and extraversion predicting healthier behaviors. Individual characteristics in feeling, thinking, and behaving can be useful in understanding psychological elements underneath health behaviors and thus motivating and facilitating behavior change by more personality-based interventions. In the future, studies are encouraged to focus on theoretically meaningful stages of life and extend the follow-up period, for example, from middle adulthood to later adulthood when several normative work- and family-related life transitions (e.g. retirement and grandparenthood) are encountered since they may modify health behaviors (Kesavayuth et al., 2018).

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Disclosure statement

No potential conflict of interest was reported by the authors.

Authors' contributions

J.A. contributed to conceptualization, formal analysis, investigation, data curation, and writing—original draft, and funding acquisition; T.K. contributed to conceptualization, investigation, data curation, writing—review & editing, and supervision; M.-L.K. contributed to investigation, writing—review & editing, and supervision; A.T. contributed to formal analysis, and writing—review & editing; T.P. contributed to investigation, and writing—review & editing; L.P. contributed to investigation, writing—review & editing, and funding acquisition; M.S. contributed to investigation, data curation, writing—review & editing, and project administration; K. K. contributed to conceptualization, investigation, data curation, writing—review & editing, supervision, project administration, and funding acquisition. The authors read and approved the submitted manuscript.

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Data availability statement

Due to sensitivity of the data and privacy of the participants, the law dictates that the data cannot be openly shared. Except for the most recent, age-61, data, the data are stored in the Finnish Social Science Data Archive (FSD) (https://www.fsd.uta.fi/en/). The data analyses that

support the findings of the present article are available from the corresponding author upon reasonable request. Pseudonymized datasets are available to external collaborators upon agreement on the terms of data use and publication of results. To request the data please contact the Principal Investigator Dr. Katja Kokko (katja.r.kokko@jyu.fi).

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