

BMJ Open Predictors of physical activity among older adults in Germany: a nationwide cohort study

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ABSTRACT

Objectives To investigate individual, interpersonal and environmental baseline factors predicting regular aerobic physical activity (PA) participation among older adults in Germany at follow-up 12 years later.

Design Population-based cohort study.

Setting Cluster-randomised general population sample selected based on population registry address information from 130 nationally distributed sample points collected from 1997 to 1999 and re-evaluated 12 years later from 2008 to 2011.

Participants 1184 adults, aged 65 years or older at follow-up with complete data at baseline and follow-up, were included in the final study sample.

Outcome measure Regular 'aerobic PA ≥ 1 day/week' assessed based on self-reported information.

Results At follow-up, 53.2% of the participants engaged in aerobic PA ≥ 1 day/week. Participants aged 50 to 60 years at baseline were more likely to engage in aerobic PA ≥ 1 day/week than participants aged 61 to 78 years; OR 1.88, 95% CI 1.46 to 2.40. Participants with middle and high socioeconomic status (SES) were more likely to engage in aerobic PA ≥ 1 day/week than participants with low SES; OR middle SES 2.08, 1.33 to 3.25; high SES 3.44, 2.11 to 5.60. Participants with high social support were more likely to engage in aerobic PA ≥ 1 day/week at follow-up than participants with low social support; OR 1.98, 1.26 to 3.12. Furthermore, participants who engaged in leisure time PA at least once per week at baseline were more likely to engage in aerobic PA ≥ 1 day/week at follow-up than those who engaged less than once per week; OR 1.95, 1.46 to 2.60.

Conclusions Several influencing factors assessed at baseline predicted regular aerobic PA participation 12 years later. These factors should be considered when planning interventions to prevent physical inactivity in older adults. There is great potential to increase aerobic PA participation in older adults in Germany, in particular among those with low SES and low social support.

BACKGROUND

In Germany, 50% of adults aged 65 years and older suffer from at least three chronic diseases.¹ Physical activity (PA) can play a major role in preventing multimorbidity in this age group because of the wide range of health conditions which can be positively

Strengths and limitations of this study

- This study pairs some of the advantages of a nationwide, population-based survey with a cohort study design.
- Another strength is the long average follow-up period of 12 years.
- A limitation is the assessment of the outcome indicators with self-reports on physical activity level that are prone to recall and social desirability bias.
- The study sample size of 1184 persons is appropriate to conduct analysis based on the whole sample but limited to conduct subgroup analysis.

influenced by PA.² Regular PA in older adults contributes to a variety of health benefits such as lower risks of cardiovascular diseases,³ functional limitations,⁴ dementia⁵ and all-cause mortality⁶ as well as better psychological well-being.³ Furthermore, PA plays an important role in the treatment and management of many chronic diseases and conditions such as hypertension, hyperlipidaemia, type 2 diabetes and obesity.³ Low-intensity PA can improve the health status of the sedentary elderly, and moderate-intensity and vigorous-intensity aerobic PAs may be even more beneficial.^{4 7 8} WHO recommends that older adults engage in moderate-intensity aerobic PA of at least 150 min per week or vigorous-intensity aerobic PA of at least 75 min per week.⁹ However, in many countries, the majority of the elderly population does not achieve the WHO recommendation.¹⁰ In Germany, three-quarters of women and three-fifths of men aged 65 years and older engage in less than 150 min of aerobic PA per week, and half of them engage in less than 1 day per week of aerobic PA.¹¹ In the context of population ageing, this observation demonstrates the potential of PA promotion to support healthy ageing, which is defined by WHO as 'developing and maintaining the functional ability that enables well-being in older age'.²



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Therefore, to effectively promote PA and plan interventions, further knowledge is needed about factors influencing PA in older adults and groups at risk for an inactive lifestyle. Ecological models are commonly used to select and structure determinants of PA behaviour.¹² These models imply that factors from multiple levels (eg, individual, interpersonal, environment, policy and global) influence PA. PA behaviour of older adults is structured in a similar way, with multiple levels of influencing factors: individual factors, for example, age, sex and physical health^{13 14}; interpersonal factors, for example, living with a spouse and social support¹⁴ and environmental factors, for example, the built environment.^{13 15} However, the evidence in the literature on determinants of regular PA in older adults based on cohort study data is limited.¹³

This study aimed to investigate predictors of regular aerobic PA among older adults living in Germany using data from a nationwide, population-based cohort study.

METHODS

Study design and participants

Data from the German National Health Interview and Examination Survey for adults 1997–1999 (GNHIES98) baseline survey and its first follow-up wave 2008–2011 (DEGS1) were used. GNHIES98 and DEGS1 are components of the national German Federal Health Monitoring programme, operated by the Robert Koch Institute, which monitors the health status and health behaviour of adults 18 years and older in Germany. The survey study design is described in detail elsewhere.^{16 17} In summary, GNHIES98 and DEGS1 are both nationwide, population-based health examination surveys. Individuals from the general adult population were randomly selected in 130 nationally distributed sample points using a two-stage clustered sampling procedure: initially communities were sampled (primary sample unit) and within these communities address information was randomly drawn from local population registries. Institutionalised persons were excluded from the study sample. The GNHIES98 sample was comprised of 7124 participants between the ages of 18 and 79 years and the DEGS1 sample of 8152 participants between the ages of 18 and 91 years.^{18 19} Interviews, examinations and tests were carried out in both surveys. GNHIES98 data collection was conducted from October 1997 to March 1999, and DEGS1 data collection was conducted from November 2008 to December 2011. GNHIES98 was approved by the Board of the Federal Commissioner for Data Protection Berlin. DEGS1 was approved by the Federal and State Commissioners for Data Protection and by the ethics committee of the Charité-University Medicine Berlin (no EA2/047/08). All participants provided informed written consent.

The response rates were 61% for GNHIES98% and 62% for DEGS1.^{18 19} All GNHIES98 participants were invited to participate in the DEGS1 follow-up survey. To improve the reparticipation rate, participants who moved away or were not willing or able to visit the examination centre had

the opportunity to take part in an interview programme. GNHIES98 participants were enrolled in DEGS1 between 10 and 15 years after GNHIES98 participation; 91% participated 11 to 13 years after GNHIES98. The age range of the study sample for analysis was defined as participants aged 65 years or older at follow-up (DEGS1). This included persons who were aged 50 years or above at baseline (GNHIES98). A flow chart of participants is shown in [figure 1](#). In total, 50.5% (n=1501) of GNHIES98 participants, aged 65 years or older at follow-up, participated in DEGS1. Of the 49.5% non-participants, 19.3% (n=575) had died during the follow-up period. A lower reparticipation rate was observed for men, older participants, participants with lower socioeconomic status (SES), participants with chronic disease as well as those with lower leisure time PA (LTPA) level (online supplementary file 1). The final study sample included 1184 participants after the exclusion of participants who were younger than 65 years at follow-up (n=220) and participants with missing data for the PA outcome variable (n=97). The multivariate analysis was conducted based on a complete-case sample (n=1143); thus, an additional 41 participants were excluded due to missing data for at least one of the covariates used.

Patient and public involvement

Patients or public were not involved.

Definition of variables

Outcome variable

The participants were asked at follow-up about the number of days and the duration on an average day they engaged in physical activities which made them sweat or get out of breath in an average week. The reference period was the last 3 months. A dichotomous variable was constructed with the categories: ‘aerobic PA \geq 1 day per week’; yes/no. This cut-off point was chosen because regular aerobic PA on a weekly basis is associated with substantial health benefits.³

Predictor variables

The information used for constructing the exposure variables was assessed in the baseline survey (GNHIES98) with self-administered questionnaires, physician-administered computer-assisted personal interviews (CAPIs) or physical examinations. The variables were selected based on theories and evidence available in the literature.^{12 20} According to the ecological model, individual (demographic variables, health status), interpersonal (living with a spouse, social support), health behavioural (LTPA, participation in a health behaviour change programme, smoking status) and environmental (size of and satisfaction with the living area) factors were included in the analysis.

Individual factors

Participant SES was assessed using an index based on the educational level, household income and occupational status of the participants which has been described in

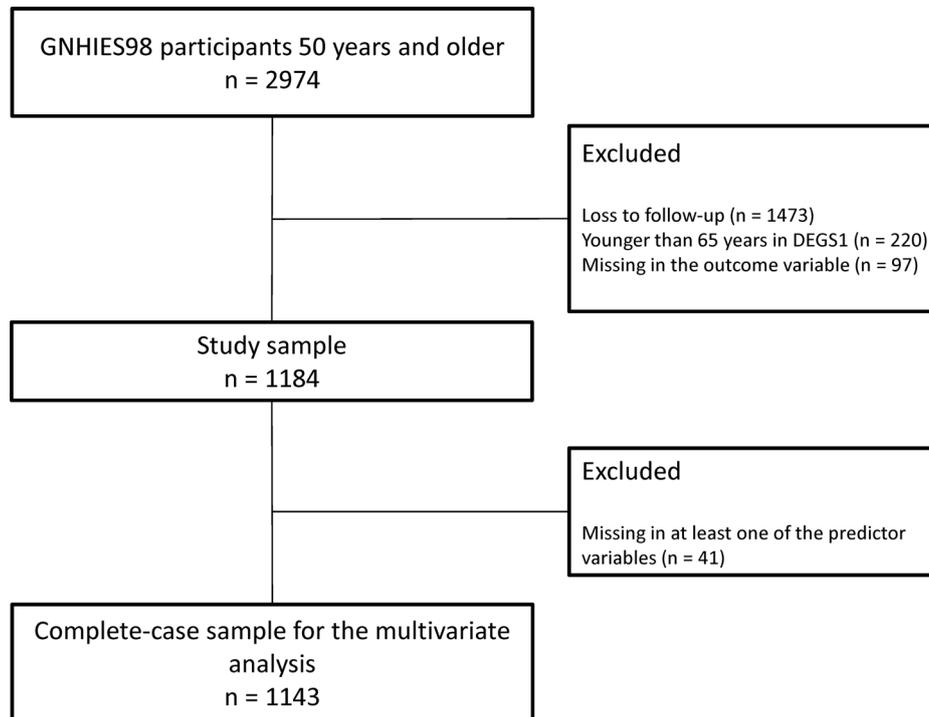


Figure 1 Flow diagram of participants. DEGS1, German National Health Interview and Examination Survey for adults first follow-up wave 2008–2011; GNHIES98, German National Health Interview and Examination Survey for adults 1997–1999.

detail elsewhere.²¹ The prevalence of chronic diseases was assessed during the CAPI. Participants were defined as ‘having a chronic disease’ if they indicated diagnosis by a physician of at least one of the following diseases: coronary heart disease, stroke, diabetes, respiratory disease or cancer. Participant body mass index (BMI) was calculated using measured participant weight and height. According to the guidelines of WHO, obesity was defined as BMI ≥ 30 kg/m².²²

Interpersonal factors

Participants were defined as ‘living with a spouse’ if they indicated marriage or cohabitation with their spouse. The question ‘How many people are so close to you that you can count on them if you have serious personal problems?’ derived from the Oslo-3 Social Support Scale²³ was used as proxy variable for social support. Two categories were constructed: ‘low social support’ (one person or none) and ‘high social support’ (at least two persons).

Behavioural factors

LTPA was assessed with the question, ‘On average, how often do you do sports activities or other physical activities in your leisure time, which make you sweat or out of breath?’. The five answer categories were summarised into two categories: ‘weekly LTPA’ (daily/3 to 6 times a week/1 to 2 times a week) and ‘no weekly LTPA’ (once a month/never). ‘Participation in at least one health behaviour change programme’ (abbreviated as ‘at least one health programme’) was defined if participants reported participation in a programme with the topic ‘weight reduction’, ‘healthy nutrition’, ‘back training’

or ‘stress management’ during the last 12 months.²⁴ The variable should be an indicator for health-oriented behaviour. Participants were defined as ‘smoker’ if they reported that they currently smoke and were defined as ‘non-smoker’ if they identified as a former smoker or as having never smoked.

Environmental factors

A ‘residential area size’ variable was constructed with four categories: ‘rural area’ (<5000 inhabitants), ‘small-sized city’ (5000–<20 000 inhabitants), ‘medium-sized city’ (20 000–<100 000 inhabitants) and ‘metropolitan city’ (≥ 100 000 inhabitants). For a subjective estimation of the environment, participants were asked to rate ‘satisfaction with their living area’ on a seven-point scale (from 1 ‘very unsatisfied’ to 7 ‘very satisfied’). A dichotomous variable was constructed with the categories ‘not satisfied’ (points 1–5) and ‘satisfied’ (points 6 and 7).

Statistical analyses

All statistical analyses were performed with the survey design procedure of STATA V.14.1 to adjust for cluster design. P values less than 0.05 were defined as statistically significant. Predictors of aerobic PA ≥ 1 day/week were investigated in two steps: first, bivariate analyses were performed and second, exposure variables that were significantly associated with the outcome in the bivariate analysis ($p < 0.05$) were included in a stepwise logistic regression analysis. Bivariate associations between the exposure and outcome variables were analysed with the Pearson’s chi-squared test with Rao-Scott correction. In the logistic regression, ORs and 95% CIs were estimated

to examine the associations between baseline exposure variables and participation in aerobic PA ≥ 1 day/week at follow-up. During the stepwise analysis, three models were investigated: Model 1 included individual factors (sex, age, SES, chronic disease and obesity); in Model 2, the interpersonal factors living with a spouse and social support were added and in Model 3, the behavioural variables were added (LTPA, at least one health programme). To detect multicollinearity between the covariates, variance inflation factors (VIFs) were calculated. All VIFs were less than 1.5 and thus clearly lower than the common threshold for multicollinearity of 10.²⁵ To investigate whether the predictors of aerobic PA ≥ 1 day/week differ between men and women and between different age groups, age and sex interaction analyses were performed for all associations presented in Model 3.

RESULTS

Participants

In total, 52.5% (n=622) of the participants were women. The mean age of the participants at baseline was 60 years (range 50–78 years) and at follow-up 72 years (range 65–91 years). Overall, 60.2% (n=713) were in the age group '50–60 years' at baseline and 39.8% (n=471) in the age group '61–78 years'. The description of the participants according to sociodemographic, health-related, interpersonal, behavioural and environmental variables at baseline is presented in table 1. When comparing participants from the older age group (61–78 years) to participants from the younger age group (50–60 years) at baseline, older participants had high SES less often, had a chronic disease more often, lived with a spouse less often, participated in LTPA less often, participated in a health programme less often and smoked less often than younger participants (each $p < 0.05$).

Aerobic PA ≥ 1 day/week

In total, 53.2% of the participants engaged in aerobic PA ≥ 1 day/week at follow-up. No significant difference was observed between men and women (55.3% vs 51.3%; $p = 0.158$). The prevalence of engaging in aerobic PA ≥ 1 day/week (41.2%) was lower at baseline among the 61-year to 78-year age group than among the 50-year to 60-year age group, where prevalence was 61.2% ($p < 0.001$). The prevalence of aerobic PA ≥ 1 day/week according to baseline sociodemographic, health-related, behavioural, social and environmental variables is shown in table 2.

Predictors of engaging in aerobic PA ≥ 1 day/week

Binary analyses showed (table 2) that age, SES, chronic disease, obesity, living with a spouse, social support, LTPA and participation in at least one health programme at baseline were significantly associated with aerobic PA ≥ 1 day/week at follow-up.

Multivariable analyses showed that age, SES, social support and LTPA were predictors for aerobic PA ≥ 1 day/

week at follow-up (table 3). The results of Model 3 (all binary significant variables included) indicated that participants aged 50 to 60 years were more likely to engage in aerobic PA ≥ 1 day/week than participants aged 61 to 78 years, with an OR of 1.88 (95% CI 1.46 to 2.40). Participants with middle or high SES were more likely to engage in aerobic PA ≥ 1 day/week than participants with low SES, with an OR of 2.08 (1.33 to 3.25) for middle SES and 3.44 (2.11 to 5.60) for high SES. Participants with high social support were more likely to engage in aerobic PA ≥ 1 day/week at follow-up than participants with a low social support, with an OR of 1.98 (1.26 to 3.12). Furthermore, participants who participate in LTPA every week at baseline were more likely to engage in aerobic PA ≥ 1 day/week at follow-up than inactive participants, with an OR of 1.95 (1.46 to 2.60).

Subgroup analyses

The interaction analyses showed that age was an effect modifier for the association between SES and aerobic PA ≥ 1 day/week and for the association between social support and aerobic PA ≥ 1 day/week (interaction term age*middle SES: $p = 0.033$; age*high SES: $p < 0.001$; age*social support: $p < 0.001$). Subgroup analyses showed that SES was a significant determinant of aerobic PA ≥ 1 day/week only in the age group 65 to 72 years but not in the age group 73 to 91 years. Participants in this age group with middle or high SES were more likely to engage in aerobic PA ≥ 1 day/week than participants with low SES (middle SES: 3.02, 1.70 to 5.37; high SES: 6.62, 3.74 to 11.72). Furthermore, social support was only a significant determinant of aerobic PA ≥ 1 day/week among participants 65 to 72 years. Participants in this age group with higher social support were more likely to engage in aerobic PA ≥ 1 day/week, with an OR of 3.31 (1.76 to 6.21). Sex was not an effect modifier for any of the presented associations.

DISCUSSION

In this nationwide, population-based cohort study, it was observed that half of the older adults 65+ years in Germany did not engage in aerobic PA at least 1 day per week. The multivariable analyses showed that the groups at high risk for having an inactive lifestyle at age 65+ years were those who, 12 years earlier, were in the older age groups, those with low socioeconomic position, low social support and low previous levels of PA. Several additional determinants of aerobic PA identified in binary analyses were no longer associated with the outcome after multivariable adjustment.

Individual factors

Sex was not a predictor for aerobic PA ≥ 1 day/week in older adults in the present study. Other studies with older adults showed mixed results with a tendency to report a higher PA level for men.^{10 13 14} A time trend analysis on the prevalence of physical inactivity among German adults aged 25 to 69 years over an observation period of

Table 1 Baseline characteristics of the study sample (n=1184)

	Missing	Age at baseline						P value
		50–60years		61–78years		Total		
		%	95% CI	%	95% CI	%	95% CI	
Individual factors								
Sex	0							
Women (n=622)		53.0	(49.5 to 56.5)	51.8	(48.2 to 55.3)	52.5	(49.8 to 55.3)	0.600
Men (n=562)		47.0	(43.5 to 50.5)	48.2	(44.7 to 51.8)	47.5	(44.7 to 50.2)	
Socioeconomic status	14							
Low (n=151)		11.4	(8.9 to 14.4)	15.2	(11.9 to 19.2)	12.9	(10.6 to 15.7)	<0.001
Middle (n=712)		57.5	(53.5 to 61.3)	66.0	(61.6 to 70.1)	60.9	(57.8 to 63.8)	
High (n=307)		31.2	(27.3 to 35.3)	18.8	(15.0 to 23.3)	26.2	(23.0 to 29.7)	
Chronic disease	3							
No (n=869)		78.5	(75.4 to 81.4)	66.0	(61.6 to 70.2)	73.6	(70.8 to 76.2)	<0.001
Yes (n=312)		21.5	(18.6 to 24.6)	34.0	(29.8 to 38.4)	26.4	(23.8 to 29.2)	
Obesity	3							
Yes (n=297)		24.5	(20.8 to 28.5)	26.2	(22.3 to 30.4)	25.1	(22.2 to 28.4)	0.504
No (n=884)		75.5	(71.5 to 79.2)	73.8	(69.6 to 77.7)	74.9	(71.6 to 77.8)	
Interpersonal factors								
Living with a spouse	16							
No (n=216)		16.7	(14.0 to 19.7)	21.2	(17.7 to 25.3)	18.5	(16.2 to 21.1)	0.035
Yes (n=952)		83.3	(80.3 to 86.0)	78.8	(74.7 to 82.3)	81.5	(78.9 to 83.8)	
Social support	21							
Low (n=100)		7.6	(5.7 to 10.0)	10.2	(7.8 to 13.1)	8.6	(7.0 to 10.5)	0.110
High (n=1063)		92.4	(90.0 to 94.3)	89.8	(86.9 to 92.2)	91.4	(89.5 to 93.0)	
Behavioural factors								
Leisure time physical activity	26							
Every week (n=784)		72.1	(67.9 to 76.0)	61.0	(56.8 to 65.1)	67.7	(64.4 to 70.9)	<0.001
Not every week (n=374)		27.9	(24.0 to 32.1)	39.0	(34.9 to 43.2)	32.3	(29.1 to 35.6)	
At least one health programme	0							
Yes (n=124)		12.6	(10.4 to 15.3)	7.2	(5.2 to 10.0)	10.5	(8.8 to 12.5)	0.002
No (n=1060)		87.4	(84.7 to 89.6)	92.8	(90.0 to 94.8)	89.5	(87.5 to 91.2)	
Smoking status	11							
Smoker (n=188)		20.0	(17.2 to 23.0)	10.1	(7.5 to 13.3)	16.0	(14.0 to 18.2)	<0.001
Non-smoker (n=985)		80.0	(77.0 to 82.8)	89.9	(86.7 to 92.5)	84.0	(81.8 to 86.0)	
Environmental factors								
Residential area size	0							
Rural (n=249)		20.3	(13.5 to 29.4)	22.1	(14.4 to 32.2)	21	(14.2 to 30.0)	0.601
Small-sized city (n=247)		20.1	(13.3 to 29.1)	22.1	(14.4 to 32.3)	20.9	(14.0 to 30.0)	
Medium-sized city (n=318)		26.9	(19.0 to 36.7)	26.8	(18.5 to 37.0)	26.9	(19.1 to 36.3)	
Metropolitan city (n=370)		32.7	(23.7 to 43.1)	29.1	(20.4 to 39.7)	31.3	(22.7 to 41.4)	
Satisfaction with residential area	21							
Not satisfied (n=308)		26.1	(22.9 to 29.7)	27.0	(23.3 to 31.0)	26.5	(23.9 to 29.2)	0.733
Satisfied (n=855)		73.9	(70.3 to 77.1)	73.0	(69.0 to 76.7)	73.5	(70.8 to 76.1)	

Table 2 Bivariate associations between aerobic PA ≥ 1 day/week and potential predictor variables

	Aerobic PA ≥ 1 day/week				P values*
	Yes		No		
	%	95% CI	%	95% CI	
1 Sex					
Women (n=622)	48.7	(44.7 to 52.7)	51.3	(47.3 to 55.3)	0.158
Men (n=562)	44.7	(40.1 to 49.4)	55.3	(50.6 to 59.9)	
Age group					<0.001
50–60 years (n=713)	38.8	(35.1 to 42.8)	61.2	(57.2 to 64.9)	
61–78 years (n=471)	58.8	(54.1 to 63.4)	41.2	(36.6 to 45.9)	
Socioeconomic status					
Low (n=151)	70.2	(62.0 to 77.3)	29.8	(22.7 to 38.0)	<0.001
Middle (n=712)	47.9	(43.8 to 52.0)	52.1	(48.0 to 56.2)	
High (n=307)	31.9	(27.0 to 37.3)	68.1	(62.7 to 73.0)	
Chronic disease					
No (n=869)	44.1	(40.5 to 47.7)	55.9	(52.3 to 59.5)	0.006
Yes (n=312)	53.8	(47.6 to 60.0)	46.2	(40.0 to 52.4)	
Obesity					
Yes (n=297)	53.5	(47.4 to 59.5)	46.5	(40.5 to 52.6)	0.005
No (n=884)	44.6	(41.2 to 48.0)	55.4	(52.0 to 58.8)	
2 Living with a spouse					
No (n=216)	57.4	(51.1 to 63.4)	42.6	(36.6 to 48.9)	<0.001
Yes (n=952)	44.1	(40.5 to 47.8)	55.9	(52.2 to 59.5)	
Social support					
Low (n=100)	65.0	(55.4 to 73.5)	35.0	(26.5 to 44.6)	<0.001
High (n=1063)	44.9	(41.6 to 48.2)	55.1	(51.8 to 58.4)	
Leisure time PA					
Every week (n=784)	38.6	(34.8 to 42.6)	61.4	(57.4 to 65.2)	<0.001
Not every week (n=374)	62.8	(57.6 to 67.8)	37.2	(32.2 to 42.4)	
3 At least one health programme					
Yes (n=124)	34.7	(26.7 to 43.6)	65.3	(56.4 to 73.3)	0.005
No (n=1060)	48.2	(44.8 to 51.7)	51.8	(48.3 to 55.2)	
Smoking status					
Smoker (n=188)	49.5	(41.7 to 57.3)	50.5	(42.7 to 58.3)	0.406
Non-smoker (n=985)	46.0	(42.5 to 49.5)	54.0	(50.5 to 57.5)	
4 Residential area size					
Rural (n=249)	48.6	(42.1 to 55.1)	51.4	(44.9 to 57.9)	0.873
Small-sized city (n=247)	48.2	(39.4 to 57.1)	51.8	(42.9 to 60.6)	
Medium-sized city (n=318)	45.9	(39.6 to 52.4)	54.1	(47.6 to 60.4)	
Metropolitan city (n=370)	45.4	(40.5 to 50.4)	54.6	(49.6 to 59.5)	
Satisfaction with residential area					0.711
Not satisfied (n=308)	47.1	(42.0 to 52.2)	52.9	(47.8 to 58.0)	
Satisfied (n=855)	46.0	(42.2 to 49.7)	54.0	(50.3 to 57.8)	

1: individual factors; 2: interpersonal factors; 3: behavioural factors; 4: environmental factors.

*Pearson's chi-squared test with Rao-Scott correction.

PA, physical activity.

20 years demonstrated that gender differences observed in the first 1990–1992 survey diminished over time so that women were no longer more inactive than men in the

2008–2011 survey.²⁶ The higher proportion of women than men aged 65 years and older living in Germany participating in PA courses as part of primary prevention

Table 3 Stepwise-adjusted ORs of aerobic PA at follow-up by baseline predictor variables, adults aged 65 years or older

Baseline variables	Aerobic PA ≥ 1 day/week					
	Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI
Sex						
Women	0.95	(0.73 to 1.23)	1.01	(0.78 to 1.32)	1.05	(0.80 to 1.38)
Men	1.00	–	1.00	–	1.00	–
Age group						
50–60 years	2.00	(1.56 to 2.56)	1.97	(1.53 to 2.52)	1.88	(1.46 to 2.40)
61–78 years	1.00	–	1.00	–	1.00	–
Socioeconomic status						
Low	1.00	–	1.00	–	1.00	–
Middle	2.48	(1.61 to 3.84)	2.39	(1.54 to 3.70)	2.08	(1.33 to 3.25)
High	4.52	(2.83 to 7.23)	4.29	(2.67 to 6.90)	3.44	(2.11 to 5.60)
Chronic disease						
No	1.25	(0.92 to 1.69)	1.24	(0.91 to 1.69)	1.21	(0.89 to 1.66)
Yes	1.00	–	1.00	–	1.00	–
Obesity						
No	1.23	(0.93 to 1.62)	1.24	(0.94 to 1.63)	1.14	(0.86 to 1.52)
Yes	1.00	–	1.00	–	1.00	–
Living with a spouse						
Yes			1.36	(1.00 to 1.84)	1.31	(0.96 to 1.79)
No			1.00	–	1.00	–
Social support						
High			2.11	(1.35 to 3.30)	1.98	(1.26 to 3.12)
Low			1.00	–	1.00	–
Leisure time physical activity						
Every week					1.95	(1.46 to 2.60)
Not every week					1.00	–
At least one health programme						
Yes					1.36	(0.88 to 2.10)
No					1.00	–

Bold, $p < 0.05$; Model 1: individual factors; Model 2: +interpersonal factors; Model 3: +behavioural factors. PA, physical activity.

programmes²⁴ might explain the similar PA prevalence in this study.

The observed lower odds for participation in aerobic PA ≥ 1 day/week with higher age in the present study are consistent with other studies.^{10 13 14 27} The loss of physical function as well as the fear of injuries and falling may play a role in the reduction of the PA level with progression of age.²⁸ A qualitative study showed that older adults still believe that PA is inappropriate for older people and might be even harmful.^{28 29} Furthermore, a cohort effect might explain, at least partly, the differences between age groups. Beginning in the 1970s, the number of recreational sport offers started to increase in Germany,³⁰ thus the younger age group in the previously mentioned study

(22–32 years old in 1970) might have benefited more than the older age group.

Consistent with the findings reported in other studies, older adults with higher SES participated more often in aerobic PA ≥ 1 day/week later in life than persons with low SES.^{14 27 31} More social and material resources and more PA friendly neighbourhoods may partly explain the higher activity level of older adults with a higher SES.^{31 32} Another important factor might be the difference in PA behaviour earlier in life. Adults with higher levels of education are more physically active in leisure time, perhaps to compensate for work-related inactivity, whereas adults with lower levels of education may have higher PA level during their work time.^{33 34} With age and retirement, it is likely that

adults who participate in LTPA continue these activities, whereas adults who had only experienced work-related activity may become inactive.

The results of this study suggest that chronic disease developed earlier in life is not a predictor of aerobic PA ≥ 1 day/week in older adults. A cross-sectional study³¹ also observed no relationship between diabetes and hypertension and PA in older adults. However, other prospective studies showed that older adults with poor health status were less likely to be physically active.^{13 14 35}

Prescribed PA is part of the therapy of several chronic diseases such as heart disease and diabetes. Thus, chronic diseases can act as both barriers to or motivations for PA, which may blur the association over time. It is possible that such a blurring of the association between chronic disease and PA may have occurred in our study. Moreover, participants with chronic diseases had a lower probability of reparticipation (see online supplementary file 1), reducing the possibility of rigorously investigating the long-term association between chronic diseases and aerobic PA ≥ 1 day/week in our study sample.

Furthermore, obesity was not a predictor of the outcome aerobic PA ≥ 1 day/week. Results of prospective studies investigating the influence of obesity on PA in the elderly are inconsistent. The authors of a review concluded that the influence of obesity on PA is weak,¹⁴ whereas the results of the English Longitudinal Study of Ageing observed that obesity is associated with a lower likelihood of being persistently active.²⁷ Similar to chronic diseases, obesity may, on the one hand, result in a lower PA level or, on the other hand, as part of a therapy may encourage an increase in activity level. The different directions of this association make it difficult to evaluate the effect of obesity on PA.

Interpersonal factors

The results of this study suggest that interpersonal factors are important predictors of engaging in aerobic PA ≥ 1 day/week in older adults. Participants with higher social support were more likely to participate in aerobic PA ≥ 1 day/week. Social networks could promote PA among older adults by providing information, connecting older adults to resources, such as transport services, and providing encouragement.^{28 32} The results are in line with a cross-sectional study which observed that in elderly people, social isolation is related to negative health behaviour such as physical inactivity.^{36 37} Living with a spouse was not a significant predictor in this analysis but older adults with a partner tended to be more physically active. Further studies observed that older adults who are married are more likely to participate in physical activities later in life.¹⁴

Behavioural factors

In the current study, former weekly LTPA was a predictor of aerobic PA ≥ 1 day/week in older adults. Several studies observed that PA participation earlier in life is an important determinant of physical behaviour among older adults, in

line with our observations.^{29 38} Experiences about physical competence as well as a positive attitude towards PA could explain the tracking of PA behaviour later in life.²⁹

Participation in at least one PA-related health programme was not a significant predictor of aerobic PA ≥ 1 day/week 12 years later. It could be that programmes, such as back training and stress management, did not prioritise the promotion of aerobic PA, and thus that participation in these programmes had no positive effect on aerobic PA ≥ 1 day/week. It could also be that the programmes increased PA level in short-term, but there were no long-term effects on aerobic PA level 12 years later.

In this study, smoking was not associated with aerobic PA ≥ 1 day/week later in life, contrary to studies demonstrating that health risk behaviour such as smoking and physical inactivity often cluster.^{14 27} Due to the high proportion of adults aged 65 years and older living in Germany who quit smoking,³⁹ an explanation for the absence of an association between smoking and PA later in life might be that many participants quit smoking during the follow-up period.

Environmental factors

The environmental factors investigated in the current study did not predict aerobic PA ≥ 1 day/week in older adults. Environmental characteristics such as urbanisation and satisfaction with the living area are probably long-term characteristics, for which the impact on individual PA behaviour may already have appeared earlier in life. Also, after adjustment for intermediate variables such as PA at baseline, the additional contribution seems small. Furthermore, participants might have moved to another residential area so that the former residential area has minor influence on the activity behaviour 12 years later. Two reviews investigated the relationship between the environmental factors within the neighbourhood and PA in older adults and came up with contradictory findings. The authors of one review⁴⁰ concluded that the majority of studies reviewed observed no relationship between environmental factors (objectively and subjectively measured) and PA behaviour of older adults. The authors of the other review¹⁵ determined that characteristics of the built environment (objectively measured) are associated with the PA of older adults. Differences in the assessment of environmental characteristics as well as PA could be reasons for the differing results.

Age interactions

SES and social support were not significant predictors of aerobic PA ≥ 1 day/week in the older age group but were significant predictors in the younger age group. One explanation for this could be a decline in the prevalence of aerobic PA with increasing age leading to weaker influence of the predictors. A lower PA prevalence also leads to a lower statistical power to determine significant associations.

Strengths and limitations

This study pairs some of the advantages of a nationwide, population-based survey with a high degree of representativeness and a cohort study design which provides stronger information on causal inference. Great efforts were made at all stages while conducting GNHIES89 and DEGS1 to reduce potential sources of bias.^{16 17} This comprised measures such as internal and external quality control during field work, anonymous data collection and record keeping, data quality assurance and use of accurate instruments. However, self-reports on PA level are prone to recall and social desirability bias.⁴¹ Thus, we cannot exclude the possibility that aerobic PA ≥ 1 day/week was over-reported. Also, most of the independent variables were based on self-reports involving the potential of reporting bias. Selection bias could have appeared at different stages (selection of individuals into the study, loss to follow-up, item non-response). This may have influenced the results and may compromise the generalisability of the findings. For instance, we were not able to consider information from participants who had died during the follow-up period. Non-response analysis indicates that the non-responders were older, had a lower level of LTPA and SES on average and more often chronic diseases and obesity compared with the responders. This suggests that the responders are a healthier and fitter group than the non-responders, and that the prevalence of aerobic PA ≥ 1 day/week at follow-up might be overestimated. In addition, the study results might not apply to elderly individuals living in a nursing home who were not eligible for inclusion into the study sample.

CONCLUSION

Despite limitations, we conclude that several influencing factors assessed at baseline predicted regular aerobic PA participation 12 years later. These factors should be considered when planning interventions to prevent physical inactivity in older adults. Aerobic PA has many benefits for ageing people and can improve their life in many ways. There is great potential for increasing aerobic PA participation in older adults in Germany. Low PA levels among older adults indicate the need for PA promotion interventions tailored for this age group. Measures promoting a physically active lifestyle during middle age, for example, through workplace interventions, may have positive long-term effects on PA level at older age due to the strong tracking of PA behaviour. Target groups for PA interventions at middle age should be people with low SES and low social support to prevent low PA levels later in life.

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writing of the manuscript. All authors contributed to the interpretation of findings, reviewed, edited and approved the final manuscript.

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