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Determinants of physical activity among older adults in Germany – a nationwide cohort study

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Abstract

Objectives

To investigate individual, interpersonal and environmental determinants of regular aerobic physical activity (PA) participation among older adults in Germany.

Design

Population-based cohort study.

Setting

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

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; odds ratio (OR): 1.88, 95% CI: 1.46-2.40. 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, 1.33-3.25; high SES 3.44, 2.11-5.60. 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, 1.26-3.12. 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, 1.46-2.60.

Conclusions

Several influencing factors assessed at middle age predicted regular aerobic PA participation twelve 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.

Keywords

Physical activity, determinants, healthy aging, older people, Germany

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 sub-group analysis

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 to prevent multimorbidity in this age group because of the wide range of health conditions which can be positively 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], dementia [5] and all-cause mortality [6] as well as a better psychological wellbeing [3]. Furthermore, PA plays an important role in the treatment and management of many chronic diseases and conditions such as hypertension, hyperlipidemia, type 2 diabetes and obesity [3]. Low intensity PA can improve the health status of the sedentary elderly and moderate and vigorous intensity aerobic PAs may be even more beneficial [4, 7, 8]. The World Health Organization (WHO) recommends that older adults engage in moderate intensity aerobic PA of at least 150 minutes per week or vigorous intensity aerobic PA of at least 75 minutes per week [9]. However, in many countries the majority of the elderly population does not achieve the WHO recommendation [10]. In Germany, three fourths of women and three fifths of men aged 65 years and older engage in less than 150 minutes of aerobic PA per week and half of them engage in less than one 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 the WHO as 'developing and maintaining the functional ability that enables well-being in older age' [2]. 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 (e.g. 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, e.g. age, sex and physical health [13, 14], interpersonal factors, e.g. living with a spouse and social support [14] and environmental factors, e.g. 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 determinants 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 1997-99 (GNHIES98) baseline survey and its first follow-up wave 2008-11 (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 of 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. Institutionalized 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 re-participation 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. 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 re-participation 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 level (Additional file 1). The final study sample included 1184 participants after 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.

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 engage in physical activities which make her or him sweat or get out of breath in an average week. The reference period was the last three months. A dichotomous variable was constructed with the categories: ‘aerobic PA ≥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 (CAPI) 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 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 the 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 co-habitation 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 Scale [23] was used as proxy variable for social support. Two categories were constructed: 'low social support' (1 person or none) and 'high social support' (at least 2 persons).

Behavioural factors

'Leisure time physical activity' (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 2 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 twelve 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); 'metropolitan city' (≥ 100,000 inhabitants). For a subjective estimation of the environment, participants were asked to rate the 'satisfaction with their living area' on a 7-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 14.1 to adjust for cluster design. P-values less than 0.05 were defined as statistically significant. Determinants 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 ($p < .05$) 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, odds ratios (OR) and 95 % confidence intervals

(CI) 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, in Model 3 the behavioural variables were added (LTPA, at least one health programme). To detect multicollinearity between the covariates, variance inflation factors (VIF) 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 determinants 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 the Model 3.

Results

Participants

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). 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 socio-demographic, 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 spouseless often, participated in LTPA less often, participated in a health programme less often and smoked less often than younger participants (each $p < .05$).

Aerobic PA ≥1 day/week

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 %; $p = .158$). The prevalence of engaging in

aerobic PA ≥1 day/week (41.2 %) was lower at baseline among the 61-78 year age group than among the 50-60 year age group, where prevalence was 61.2 % ($p < .001$). The prevalence of aerobic PA ≥1 day/week according to baseline socio-demographic, health-related, behavioural, social and environmental variables is shown in Table 2.

Determinants 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.

Multivariate 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, 1.46-2.40). 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 (1.33-3.25) for middle SES and 3.44 (2.11-5.60) 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 (1.26-3.12). 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 (1.46-2.60).

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: $p = .033$; age*high SES: $p < .001$; age*social support: $p < .001$). 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, 1.70-5.37; high SES: 6.62, 3.74-11.72). 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 (1.76-6.21). 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 one day per week. The multivariate 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 socio-economic 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 multivariate adjustment.

Individual factors

Sex was not a determinant 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 20 years demonstrated that gender differences observed in the first 1990-92 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 programmes [24] 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 at the year 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 leisure time PA 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 study [31] 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 like 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 re-participation (see Additional File 1), reducing the possibility to rigorously investigate 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 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 Aging 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 determinants 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 physical activity 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 like 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 physical 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 twelve years later. It could be that programmes such as back training and stress

management, did not prioritize 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 twelve 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 like 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 no 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 urbanization and satisfaction with the living area are probably long-term characteristics, for which the impact on individual PA behaviour may already has appeared earlier in life. Also after adjustment for intermediate variables, like 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 twelve 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 review [40] 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 review [15] 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 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 gives stronger information on causal inference. High efforts were undertaken at all stages of 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 generalizability of the findings. For instance, we were not able to consider information of participants who had died during the follow-up period. Non-response analysis indicates that the non-responders were older, they had on average a lower level of LTPA and SES and more often chronic diseases and obesity compared to 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 middle age predicted regular aerobic PA participation twelve years later. These factors should be considered when planning interventions to prevent physical inactivity in older adults. Aerobic PA has many benefits for aging people and can improve their life in many ways. There is a great potential to increase 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, e.g. 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.

Additional material

Additional File 1: DEGS1 unit nonresponse analysis, differences in selected baseline characteristics between DEGS1 non-respondents and respondents.

Abbreviations

BMI – body mass index; CAPI – physician-administered computer assisted personal interview; DEGS – German Health Interview and Examination Survey for Adults 2008-11; GNHIES98 – German National Health Interview and Examination Survey 1997-99; OR – odds ratio; PA – physical activity; SES – socioeconomic status; WHO – World Health Organization

Declarations

Ethics approval and consent to participate

The study GNHIES98 was approved by the Board of the Federal Commissioner Data Protection Berlin. DEGS1 was approved by the Federal and State Commissioners for Data Protection and by the Charité – University Medicine Berlin ethic committee (No. EA2/047/08). All participants provided informed written consent.

Consent for publication

Not applicable.

Competing interests

The authors declare that they do have no competing interests.

Availability of data and materials

Datasets of GNHIES98 and DEGS1 are available via Public Use File (http://www.rki.de/DE/Content/Gesundheitsmonitoring/Forschungsdatenzentrum/informationen_antrag/info_antrag_node.html).

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Authors' contributions

GBMM was involved in the design and conduct of GNHIES98 and DEGS1 in particular for the physical activity questions. SK and KM conceptualized the current study. KM conducted the present analysis and GBMM, SJ, AS and JDF contributed to the analysis plan and interpretation of the results. KM drafted the manuscript and GBMM, SJ, AS, SK and JDF critically revised it. JDF contributed to writing the manuscript. All authors read and approved the final manuscript.

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Figures

Figure 1: Flow diagram of participants

509 **Tables**

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

			Age at basline						
		Missing	50-60 years		61-78 years		Total		*p*-value
			%	95% CI	%	95% CI	%	95% CI	
1	**Individual factors**								
	Sex	0							
	Women (n=622)		53.0	(49.5-56.5)	51.8	(48.2-55.3)	52.5	(49.8-55.3)	0.600
	Men (n=562)		47.0	(43.5-50.5)	48.2	(44.7-51.8)	47.5	(44.7-50.2)	
	Socioeconomic status	14							
	Low (n=151)		11.4	(8.9-14.4)	15.2	(11.9-19.2)	12.9	(10.6-15.7)	< 0.001
	Middle (n=712)		57.5	(53.5-61.3)	66.0	(61.6-70.1)	60.9	(57.8-63.8)	
	High (n=307)		31.2	(27.3-35.3)	18.8	(15.0-23.3)	26.2	(23.0-29.7)	
	Chronic disease	3							
	No (n=869)		78.5	(75.4-81.4)	66.0	(61.6-70.2)	73.6	(70.8-76.2)	< 0.001
	Yes (n=312)		21.5	(18.6-24.6)	34.0	(29.8-38.4)	26.4	(23.8-29.2)	
	Obesity	3							
	Yes (n=297)		24.5	(20.8-28.5)	26.2	(22.3-30.4)	25.1	(22.2-28.4)	0.504
	No (n=884)		75.5	(71.5-79.2)	73.8	(69.6-77.7)	74.9	(71.6-77.8)	
2	**Interpersonal factors**								
	Living with a spouse	16							
	No (n=216)		16.7	(14.0-19.7)	21.2	(17.7-25.3)	18.5	(16.2-21.1)	0.035
	Yes (n=952)		83.3	(80.3-86.0)	78.8	(74.7-82.3)	81.5	(78.9-83.8)	
	Social support	21							
	Low (n=100)		7.6	(5.7-10.0)	10.2	(7.8-13.1)	8.6	(7.0-10.5)	0.110
	High (n=1,063)		92.4	(90.0-94.3)	89.8	(86.9-92.2)	91.4	(89.5-93.0)	
3	**Behavioural factors**								
	Leisure time physical activity	26							
	Every week (n=784)		72.1	(67.9-76.0)	61.0	(56.8-65.1)	67.7	(64.4-70.9)	< 0.001
	Not every week (n=374)		27.9	(24.0-32.1)	39.0	(34.9-43.2)	32.3	(29.1-35.6)	
	At least one health programme	0							
	Yes (n=124)		12.6	(10.4-15.3)	7.2	(5.2-10.0)	10.5	(8.8-12.5)	0.002
	No (n=1,060)		87.4	(84.7-89.6)	92.8	(90.0-94.8)	89.5	(87.5-91.2)	
	Smoking status	11							
	Smoker (n=188)		20.0	(17.2-23.0)	10.1	(7.5-13.3)	16.0	(14.0-18.2)	< 0.001
	Non-smoker (n=985)		80.0	(77.0-82.8)	89.9	(86.7-92.5)	84.0	(81.8-86.0)	
4	**Environmental factors**								
	Residential area size	0							
	Rural (n=249)		20.3	(13.5-29.4)	22.1	(14.4-32.2)	21	(14.2-30.0)	0.601
	Small-sized city (n=247)		20.1	(13.3-29.1)	22.1	(14.4-32.3)	20.9	(14.0-30.0)	
	Medium-sized city (n=318)		26.9	(19.0-36.7)	26.8	(18.5-37.0)	26.9	(19.1-36.3)	
	Metropolitan city (n=370)		32.7	(23.7-43.1)	29.1	(20.4-39.7)	31.3	(22.7-41.4)	

Satisfaction with residential area	21							
Not satisfied (n=308)		26.1	(22.9-29.7)	27.0	(23.3-31.0)	26.5	(23.9-29.2)	0.733
Satisfied (n=855)		73.9	(70.3-77.1)	73.0	(69.0-76.7)	73.5	(70.8-76.1)	

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Table 2: Bivariate associations between aerobic physical activity ≥ 1 day/week and potential predictor variables

		Aerobic physical activity ≥ 1 day/week				
		No		Yes		
		%	95% CI	%	95% CI	p-value*
1	Sex					
	Women (n=622)	48.7	(44.7-52.7)	51.3	(47.3-55.3)	0.158
	Men (n=562)	44.7	(40.1-49.4)	55.3	(50.6-59.9)	
	Age group					
	50-60 years (n=713)	38.8	(35.1-42.8)	61.2	(57.2-64.9)	< 0.001
	61-78 years (n=471)	58.8	(54.1-63.4)	41.2	(36.6-45.9)	
	Socioeconomic status					
	Low (n=151)	70.2	(62.0-77.3)	29.8	(22.7-38.0)	< 0.001
	Middle (n=712)	47.9	(43.8-52.0)	52.1	(48.0-56.2)	
	High (n=307)	31.9	(27.0-37.3)	68.1	(62.7-73.0)	
	Chronic disease					
	No (n=869)	44.1	(40.5-47.7)	55.9	(52.3-59.5)	0.006
	Yes (n=312)	53.8	(47.6-60.0)	46.2	(40.0-52.4)	
	Obesity					
	Yes (n=297)	53.5	(47.4-59.5)	46.5	(40.5-52.6)	0.005
	No (n=884)	44.6	(41.2-48.0)	55.4	(52.0-58.8)	
2						
	Living with a spouse					
	No (n=216)	57.4	(51.1-63.4)	42.6	(36.6-48.9)	< 0.001
	Yes (n=952)	44.1	(40.5-47.8)	55.9	(52.2-59.5)	
	Social support					
	Low (n=100)	65.0	(55.4-73.5)	35.0	(26.5-44.6)	< 0.001
	High (n=1,063)	44.9	(41.6-48.2)	55.1	(51.8-58.4)	
3						
	Leisure time physical activity					
	Every week (n=784)	38.6	(34.8-42.6)	61.4	(57.4-65.2)	< 0.001
	Not every week (n=374)	62.8	(57.6-67.8)	37.2	(32.2-42.4)	
	At least one health programme					
	Yes (n=124)	34.7	(26.7-43.6)	65.3	(56.4-73.3)	0.005
	No (n=1,060)	48.2	(44.8-51.7)	51.8	(48.3-55.2)	
	Smoking status					
	Smoker (n=188)	49.5	(41.7-57.3)	50.5	(42.7-58.3)	0.406
	Non-smoker (n=985)	46.0	(42.5-49.5)	54.0	(50.5-57.5)	
4						
	Residential area size					
	Rural (n=249)	48.6	(42.1-55.1)	51.4	(44.9-57.9)	0.873
	Small-sized city (n=247)	48.2	(39.4-57.1)	51.8	(42.9-60.6)	
	Medium-sized city (n=318)	45.9	(39.6-52.4)	54.1	(47.6-60.4)	

Metropolitan city (n=370)	45.4	(40.5-50.4)	54.6	(49.6-59.5)	
Satisfaction with residential area					0.711
Not satisfied (n=308)	47.1	(42.0-52.2)	52.9	(47.8-58.0)	
Satisfied (n=855)	46.0	(42.2-49.7)	54.0	(50.3-57.8)	

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

1: Individual factors; 2: Interpersonal factors; 3: Behavioural factors; 4: Environmental factors

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Table 3: Stepwise adjusted odds ratios of aerobic physical activity at follow-up by baseline predictor variables, adults aged 65 years or older

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

Bold: p < 0.05; OR = Odds Ratio; Model 1: Individual factors; Model 2: + interpersonal factors; Model 3: + behavioural factors

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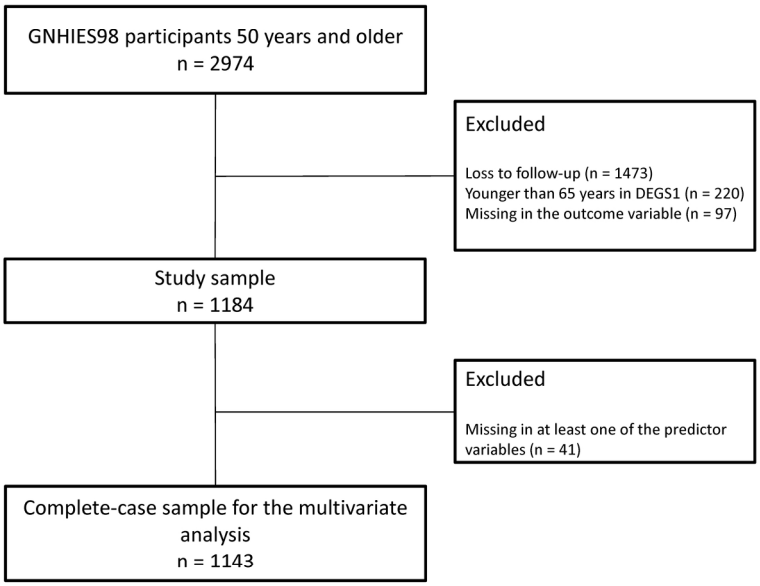

Figure 1: Flow diagram of participants

190x142mm (300 x 300 DPI)

Additional File 1 – DEGS1 unit non-response analysis

Table 1: Differences in selected baseline characteristics between DEGS1 respondents, non-respondents and deceased

	Responder		Non-responder		Deceased	
	%	95% CI	%	95% CI	%	95% CI
Total (n=2974)	50.5	(48.3-52.6)	30.2	(28.3-32.1)	19.3	(17.9-20.9)
Sex						
Women (n=1,567)	52.6	(50.2-55.0)	59.2	(56.0-62.5)	42.6	(39.0-46.3)
Men (n=1,407)	47.4	(45.0-49.8)	40.8	(37.5-44.0)	57.4	(53.7-61.0)
Age						
50-60 years (n=1,492)	65.2	(62.6-67.7)	43.2	(39.9-46.5)	21.7	(18.5-25.3)
61-78 years (n=1,482)	34.8	(32.3-37.4)	56.8	(53.5-60.1)	78.3	(74.7-81.5)
Socioeconomic status						
Low (n=566)	13.1	(10.9-15.6)	26.6	(23.0-30.6)	26.5	(22.6-30.7)
Middle (n=1,709)	60.3	(57.5-63.0)	59.4	(55.7-63.0)	55.9	(51.9-59.8)
High (n=611)	26.6	(23.6-30.0)	14.0	(11.3-17.0)	17.6	(14.2-21.6)
Chronical disease						
No (n=1,984)	74.7	(72.5-76.9)	67.0	(64.1-69.8)	46.4	(42.1-50.8)
Yes (n=980)	25.3	(23.1-27.5)	33.0	(30.2-35.9)	53.6	(49.2-57.9)
Obesity						
Yes (n=860)	26.1	(23.3-29.1)	34.0	(30.6-37.6)	29.8	(25.8-34.1)
No (n=2,087)	73.9	(70.9-76.7)	66.0	(62.4-69.4)	70.2	(65.9-74.2)
Living with a spouse						
Yes (n=2,273)	85.1	(83.1-86.8)	74.0	(70.5-77.2)	72.3	(68.1-76.2)
No (n=589)	14.9	(13.2-16.9)	26.0	(22.8-29.5)	27.7	(23.8-31.9)
Leisure time physical activity						
Every week (n=1,624)	67.6	(64.7-70.4)	46.5	(42.5-50.5)	43.8	(39.1-48.6)
Not every week (n=1,231)	32.4	(29.6-35.3)	53.5	(49.5-57.5)	56.2	(51.4-60.9)

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Reported on page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5-6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	15
Study size	10	Explain how the study size was arrived at	5 (see cited study protocol papers)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	Additional file 1
		(*e*) Describe any sensitivity analyses	15, Additional file 1
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for	6, Fig. 1

		eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	Additional file 1
		(c) Consider use of a flow diagram	Fig. 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9, Tab. 1
		(b) Indicate number of participants with missing data for each variable of interest	Tab. 1
		(c) Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	Report numbers of outcome events or summary measures over time	9-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10, Tab. 2, 3
		(*b*) Report category boundaries when continuous variables were categorized	6-8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

Predictors of physical activity among older adults in Germany – a nationwide cohort study

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

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; odds ratio (OR): 1.88, 95% CI: 1.46-2.40. 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, 1.33-3.25; high SES 3.44, 2.11-5.60. 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, 1.26-3.12. 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, 1.46-2.60.

Conclusions

Several influencing factors assessed at baseline predicted regular aerobic PA participation twelve 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.

Keywords

Physical activity, determinants, healthy aging, older people, Germany

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 sub-group analysis

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 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], dementia [5] and all-cause mortality [6] as well as better psychological wellbeing [3]. Furthermore, PA plays an important role in the treatment and management of many chronic diseases and conditions such as hypertension, hyperlipidemia, type 2 diabetes and obesity [3]. Low intensity PA can improve the health status of the sedentary elderly and moderate and vigorous intensity aerobic PAs may be even more beneficial [4, 7, 8]. The World Health Organization (WHO) recommends that older adults engage in moderate intensity aerobic PA of at least 150 minutes per week or vigorous intensity aerobic PA of at least 75 minutes 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 minutes of aerobic PA per week and half of them engage in less than one 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 the WHO as 'developing and maintaining the functional ability that enables well-being in older age' [2]. 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 (e.g. 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, e.g. age, sex and physical health [13, 14], interpersonal factors, e.g. living with a spouse and social support [14] and environmental factors, e.g. 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 1997-99 (GNHIES98) baseline survey and its first follow-up wave 2008-11 (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. Institutionalized 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 re-participation 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. 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 re-participation 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 level (Additional 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 three months. A dichotomous variable was constructed with

the categories: 'aerobic PA ≥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 (CAPI) 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 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 the 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 co-habitation 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 Scale [23] was used as proxy variable for social support. Two categories were constructed: 'low social support' (1 person or none) and 'high social support' (at least 2 persons).

Behavioural factors

'Leisure time physical activity' (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 2 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 twelve 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); 'metropolitan city' (≥ 100,000 inhabitants). For a subjective estimation of the environment, participants were asked to rate 'satisfaction with their living area' on a 7-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 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 ($p < .05$) 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, odds ratios (OR) and 95 % confidence intervals (CI) 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, in Model 3 the behavioural variables were added (LTPA, at least one health programme). To detect multicollinearity between the covariates, variance inflation factors (VIF) 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

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). 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 socio-demographic, 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 $p < .05$).

Aerobic PA ≥1 day/week

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 = .158). The prevalence of engaging in aerobic PA ≥1 day/week (41.2 %) was lower at baseline among the 61-78 year age group than among the 50-60 year age group, where prevalence was 61.2 % (p < .001). The prevalence of aerobic PA ≥1 day/week according to baseline socio-demographic, 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.

Multivariate 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, 1.46-2.40). 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 (1.33-3.25) for middle SES and 3.44 (2.11-5.60) 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 (1.26-3.12). 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 (1.46-2.60).

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 = .033; age*high SES: p < .001; age*social support: p < .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, 1.70-5.37; high SES: 6.62, 3.74-11.72). 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 (1.76-6.21). 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 one day per week. The multivariate 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 socio-economic 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 multivariate 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 20 years demonstrated that gender differences observed in the first 1990-92 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 programmes [24] 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 leisure time PA 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 study [31] 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 like 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

re-participation (see Additional 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 Aging 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 physical activity 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 like 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 physical 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 twelve years later. It could be that programmes such as back training and stress management, did not prioritize 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 twelve 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 like 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 urbanization 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 like 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 twelve 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 review [40] 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 review [15] 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 generalizability 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 to 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 twelve years later. These factors should be considered when planning interventions to prevent physical inactivity in older adults. Aerobic PA has many benefits for aging 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, e.g. 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.

Additional material

Additional File 1: DEGS1 unit nonresponse analysis, differences in selected baseline characteristics between DEGS1 non-respondents and respondents.

Abbreviations

BMI – body mass index; CAPI – physician-administered computer assisted personal interview; DEGS – German Health Interview and Examination Survey for Adults 2008-11; GNHIES98 – German National Health Interview and Examination Survey 1997-99; OR – odds ratio; PA – physical activity; SES – socioeconomic status; WHO – World Health Organization

Declarations

Ethics approval and consent to participate

The study GNHIES98 was approved by the Board of the Federal Commissioner Data Protection Berlin. DEGS1 was approved by the Federal and State Commissioners for Data Protection and by the Charité – University Medicine Berlin ethic committee (No. EA2/047/08). All participants provided informed written consent.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

Datasets of GNHIES98 and DEGS1 are available via Public Use File (http://www.rki.de/DE/Content/Gesundheitsmonitoring/Forschungsdatenzentrum/informationen_antrag/info_antrag_node.html).

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Authors' contributions

GBMM was involved in the design and conduct of GNHIES98 and DEGS1 in particular for the physical activity questions. SK and KM conceptualized the current study. KM conducted the present analysis and GBMM, SJ, AS and JDF contributed to the analysis plan and interpretation of the results. KM drafted the manuscript and GBMM, SJ, AS, SK and JDF critically revised it. JDF contributed to writing the manuscript. All authors contributed to interpretation of findings, reviewed, edited and approved the final manuscript.

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Figures

Figure 1: Flow diagram of participants

511 **Tables**

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

			Age at baseline						
		Missing	50-60 years		61-78 years		Total		*p*-value
			%	95% CI	%	95% CI	%	95% CI	
1	**Individual factors**								
	Sex	0							
	Women (n=622)		53.0	(49.5-56.5)	51.8	(48.2-55.3)	52.5	(49.8-55.3)	0.600
	Men (n=562)		47.0	(43.5-50.5)	48.2	(44.7-51.8)	47.5	(44.7-50.2)	
	Socioeconomic status	14							
	Low (n=151)		11.4	(8.9-14.4)	15.2	(11.9-19.2)	12.9	(10.6-15.7)	< 0.001
	Middle (n=712)		57.5	(53.5-61.3)	66.0	(61.6-70.1)	60.9	(57.8-63.8)	
	High (n=307)		31.2	(27.3-35.3)	18.8	(15.0-23.3)	26.2	(23.0-29.7)	
	Chronic disease	3							
	No (n=869)		78.5	(75.4-81.4)	66.0	(61.6-70.2)	73.6	(70.8-76.2)	< 0.001
	Yes (n=312)		21.5	(18.6-24.6)	34.0	(29.8-38.4)	26.4	(23.8-29.2)	
	Obesity	3							
	Yes (n=297)		24.5	(20.8-28.5)	26.2	(22.3-30.4)	25.1	(22.2-28.4)	0.504
	No (n=884)		75.5	(71.5-79.2)	73.8	(69.6-77.7)	74.9	(71.6-77.8)	
2	**Interpersonal factors**								
	Living with a spouse	16							
	No (n=216)		16.7	(14.0-19.7)	21.2	(17.7-25.3)	18.5	(16.2-21.1)	0.035
	Yes (n=952)		83.3	(80.3-86.0)	78.8	(74.7-82.3)	81.5	(78.9-83.8)	
	Social support	21							
	Low (n=100)		7.6	(5.7-10.0)	10.2	(7.8-13.1)	8.6	(7.0-10.5)	0.110
	High (n=1,063)		92.4	(90.0-94.3)	89.8	(86.9-92.2)	91.4	(89.5-93.0)	
3	**Behavioural factors**								
	Leisure time physical activity	26							
	Every week (n=784)		72.1	(67.9-76.0)	61.0	(56.8-65.1)	67.7	(64.4-70.9)	< 0.001
	Not every week (n=374)		27.9	(24.0-32.1)	39.0	(34.9-43.2)	32.3	(29.1-35.6)	
	At least one health programme	0							
	Yes (n=124)		12.6	(10.4-15.3)	7.2	(5.2-10.0)	10.5	(8.8-12.5)	0.002
	No (n=1,060)		87.4	(84.7-89.6)	92.8	(90.0-94.8)	89.5	(87.5-91.2)	
	Smoking status	11							
	Smoker (n=188)		20.0	(17.2-23.0)	10.1	(7.5-13.3)	16.0	(14.0-18.2)	< 0.001
	Non-smoker (n=985)		80.0	(77.0-82.8)	89.9	(86.7-92.5)	84.0	(81.8-86.0)	
4	**Environmental factors**								
	Residential area size	0							
	Rural (n=249)		20.3	(13.5-29.4)	22.1	(14.4-32.2)	21	(14.2-30.0)	0.601
	Small-sized city (n=247)		20.1	(13.3-29.1)	22.1	(14.4-32.3)	20.9	(14.0-30.0)	
	Medium-sized city (n=318)		26.9	(19.0-36.7)	26.8	(18.5-37.0)	26.9	(19.1-36.3)	
	Metropolitan city (n=370)		32.7	(23.7-43.1)	29.1	(20.4-39.7)	31.3	(22.7-41.4)	

Satisfaction with residential area	21							
Not satisfied (n=308)		26.1	(22.9-29.7)	27.0	(23.3-31.0)	26.5	(23.9-29.2)	0.733
Satisfied (n=855)		73.9	(70.3-77.1)	73.0	(69.0-76.7)	73.5	(70.8-76.1)	

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Table 2: Bivariate associations between aerobic physical activity ≥ 1 day/week and potential predictor variables

		Aerobic physical activity ≥ 1 day/week				
		No		Yes		
		%	95% CI	%	95% CI	p-value*
1	Sex					
	Women (n=622)	48.7	(44.7-52.7)	51.3	(47.3-55.3)	0.158
	Men (n=562)	44.7	(40.1-49.4)	55.3	(50.6-59.9)	
	Age group					
	50-60 years (n=713)	38.8	(35.1-42.8)	61.2	(57.2-64.9)	< 0.001
	61-78 years (n=471)	58.8	(54.1-63.4)	41.2	(36.6-45.9)	
	Socioeconomic status					
	Low (n=151)	70.2	(62.0-77.3)	29.8	(22.7-38.0)	< 0.001
	Middle (n=712)	47.9	(43.8-52.0)	52.1	(48.0-56.2)	
	High (n=307)	31.9	(27.0-37.3)	68.1	(62.7-73.0)	
	Chronic disease					
	No (n=869)	44.1	(40.5-47.7)	55.9	(52.3-59.5)	0.006
	Yes (n=312)	53.8	(47.6-60.0)	46.2	(40.0-52.4)	
	Obesity					
	Yes (n=297)	53.5	(47.4-59.5)	46.5	(40.5-52.6)	0.005
	No (n=884)	44.6	(41.2-48.0)	55.4	(52.0-58.8)	
2						
	Living with a spouse					
	No (n=216)	57.4	(51.1-63.4)	42.6	(36.6-48.9)	< 0.001
	Yes (n=952)	44.1	(40.5-47.8)	55.9	(52.2-59.5)	
	Social support					
	Low (n=100)	65.0	(55.4-73.5)	35.0	(26.5-44.6)	< 0.001
	High (n=1,063)	44.9	(41.6-48.2)	55.1	(51.8-58.4)	
3						
	Leisure time physical activity					
	Every week (n=784)	38.6	(34.8-42.6)	61.4	(57.4-65.2)	< 0.001
	Not every week (n=374)	62.8	(57.6-67.8)	37.2	(32.2-42.4)	
	At least one health programme					
	Yes (n=124)	34.7	(26.7-43.6)	65.3	(56.4-73.3)	0.005
	No (n=1,060)	48.2	(44.8-51.7)	51.8	(48.3-55.2)	
	Smoking status					
	Smoker (n=188)	49.5	(41.7-57.3)	50.5	(42.7-58.3)	0.406
	Non-smoker (n=985)	46.0	(42.5-49.5)	54.0	(50.5-57.5)	
4						
	Residential area size					
	Rural (n=249)	48.6	(42.1-55.1)	51.4	(44.9-57.9)	0.873
	Small-sized city (n=247)	48.2	(39.4-57.1)	51.8	(42.9-60.6)	
	Medium-sized city (n=318)	45.9	(39.6-52.4)	54.1	(47.6-60.4)	

Metropolitan city (n=370)	45.4	(40.5-50.4)	54.6	(49.6-59.5)	
Satisfaction with residential area					0.711
Not satisfied (n=308)	47.1	(42.0-52.2)	52.9	(47.8-58.0)	
Satisfied (n=855)	46.0	(42.2-49.7)	54.0	(50.3-57.8)	

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

1: Individual factors; 2: Interpersonal factors; 3: Behavioural factors; 4: Environmental factors

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Table 3: Stepwise adjusted odds ratios of aerobic physical activity at follow-up by baseline predictor variables, adults aged 65 years or older

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

Bold: p < 0.05; OR = Odds Ratio; Model 1: Individual factors; Model 2: + interpersonal factors; Model 3: + behavioural factors

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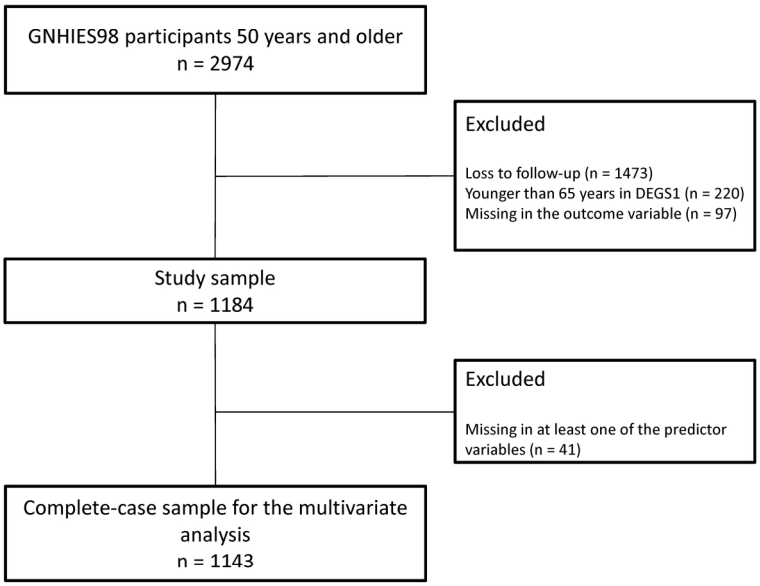

Figure 1: Flow diagram of participants

190x142mm (300 x 300 DPI)

Additional File 1 – DEGS1 unit non-response analysis

Table 1: Differences in selected baseline characteristics between DEGS1 respondents, non-respondents and deceased

	Responder		Non-responder		Deceased	
	%	95% CI	%	95% CI	%	95% CI
Total (n=2974)	50.5	(48.3-52.6)	30.2	(28.3-32.1)	19.3	(17.9-20.9)
Sex						
Women (n=1,567)	52.6	(50.2-55.0)	59.2	(56.0-62.5)	42.6	(39.0-46.3)
Men (n=1,407)	47.4	(45.0-49.8)	40.8	(37.5-44.0)	57.4	(53.7-61.0)
Age						
50-60 years (n=1,492)	65.2	(62.6-67.7)	43.2	(39.9-46.5)	21.7	(18.5-25.3)
61-78 years (n=1,482)	34.8	(32.3-37.4)	56.8	(53.5-60.1)	78.3	(74.7-81.5)
Socioeconomic status						
Low (n=566)	13.1	(10.9-15.6)	26.6	(23.0-30.6)	26.5	(22.6-30.7)
Middle (n=1,709)	60.3	(57.5-63.0)	59.4	(55.7-63.0)	55.9	(51.9-59.8)
High (n=611)	26.6	(23.6-30.0)	14.0	(11.3-17.0)	17.6	(14.2-21.6)
Chronical disease						
No (n=1,984)	74.7	(72.5-76.9)	67.0	(64.1-69.8)	46.4	(42.1-50.8)
Yes (n=980)	25.3	(23.1-27.5)	33.0	(30.2-35.9)	53.6	(49.2-57.9)
Obesity						
Yes (n=860)	26.1	(23.3-29.1)	34.0	(30.6-37.6)	29.8	(25.8-34.1)
No (n=2,087)	73.9	(70.9-76.7)	66.0	(62.4-69.4)	70.2	(65.9-74.2)
Living with a spouse						
Yes (n=2,273)	85.1	(83.1-86.8)	74.0	(70.5-77.2)	72.3	(68.1-76.2)
No (n=589)	14.9	(13.2-16.9)	26.0	(22.8-29.5)	27.7	(23.8-31.9)
Leisure time physical activity						
Every week (n=1,624)	67.6	(64.7-70.4)	46.5	(42.5-50.5)	43.8	(39.1-48.6)
Not every week (n=1,231)	32.4	(29.6-35.3)	53.5	(49.5-57.5)	56.2	(51.4-60.9)

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Reported on page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5-6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	15
Study size	10	Explain how the study size was arrived at	5 (see cited study protocol papers)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	Additional file 1
		(*e*) Describe any sensitivity analyses	15, Additional file 1
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for	6, Fig. 1

		eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	Additional file 1
		(c) Consider use of a flow diagram	Fig. 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9, Tab. 1
		(b) Indicate number of participants with missing data for each variable of interest	Tab. 1
		(c) Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	Report numbers of outcome events or summary measures over time	9-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10, Tab. 2, 3
		(*b*) Report category boundaries when continuous variables were categorized	6-8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.