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ORIGINAL ARTICLE

Differing lifecourse associations with sport-, occupational- and household-based physical activity at age 49–51 years: the Newcastle Thousand Families Study

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Abstract

Objectives We investigated the contributions of a range of factors from across life to variations in physical activity within the Newcastle Thousand Family's birth cohort.

Methods At age 49–51 years, 574 study members returned questionnaires, including details of physical activity (occupational, commuting, household and sport). Factor analysis of activity types produced two retained factor scores, 'sport' and 'other physical activity', analysed by path analysis.

Results More advantaged current social class, higher education level and not smoking were associated with increased sport activity, but not 'other physical activity'. Males had higher levels of occupational and lower levels of household activity than females. Smokers had increased work activity. Long-term illness was associated with lower activity across all types. Current social class and smoking showed the highest relative contribution for 'sport' and long-term illness for 'other physical activity'.

Conclusion Increasing activity in adults requires better understanding what the barriers to maintaining or taking on new levels of physical activity are, and long-term strategies and public health interventions need to be developed to engage adults in interesting, affordable and available activities.

Keywords Physical activity · Socioeconomic status · Early life · Lifecourse

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Introduction

Physical activity has many beneficial effects on health. It reduces the risk of cancer (Friedenreich 2010) and chronic diseases such as cardiovascular disease (Buchner 2009) and diabetes (Ahmad and Crandall 2010; Balkau et al. 2008), preserves function with ageing (Hollmann et al. 2007) and enhances psychological well-being (Fontaine 2000). Physical activity is promoted as part of a healthy lifestyle through public intervention (Change for Life 2012, UK) and guidelines (for example, in the UK at least 150 min of moderate intensity physical activity per week is recommended (World Health Organisation 2010; Physical activity for health 2012). To improve the effectiveness of interventions, it is important to identify factors that contribute to the variation in physical activity levels. Early life predictors of activity in childhood have been investigated, but findings are inconsistent (Mattocks et al. 2008; Gaysina et al. 2010). Research into the effects of early life predictors of activity in adulthood is scarce. There is a need to consider also factors from across the whole lifecourse (for example, smoking, alcohol and body mass index (BMI)) which may impact on physical activity in adulthood.

Self-reported physical activity data are typically collected by enquiring about different types of activity (such as sport, occupational, household, etc.). Many previous studies have reported on the individual types of physical activity (Gaysina et al. 2010; Droomers et al. 1998), or have included an objective measure of physical activity (Mattocks et al. 2008; Kelder et al. 1994). Through factor analysis, different types of activity can be combined to give an overall measure. This enables path analysis to be used to identify factors most strongly associated with physical activity. This information can be used to guide future public health interventions aimed at increasing physical activity. The overall aim of this study was to investigate predictive factors of physical activity in individuals aged 49–51 years. A further objective was to address the underlying components of physical activity.

Methods

Study participants

The Newcastle Thousand Families Study is a prospective study of all 1,142 individuals born in May and June 1947 to mothers resident in Newcastle upon Tyne, UK (Pearce et al. 2009). The health, growth and development of the cohort were followed in detail up to age 15 years. Throughout the first few years of the children's life, families were visited both on a routine (up to every 6 weeks during infancy and at least quarterly until age 5 years) and an ad hoc basis by the study team, which included health visitors (nurses who visited families at home and later at the children's school) and paediatricians.

The cohort underwent a major follow-up at age 49–51 years (Pearce et al. 2009). Participants were members of the cohort who were either traced through the National Health Service Central Register or contacted the study team in response to media publicity. Between October 1996 and December 1998, health and lifestyle questionnaires were sent out for completion and study members invited to attend a physiological examination which took place over the same time period. The study received ethical approval from the appropriate local research ethics committees and all study members gave their written consent.

Measurement of early life experience

Information on early life was recorded prospectively for all study members (Pearce et al. 2009). Birth weights, recorded by the midwife at the time of the child's birth, were standardised for gestational age and sex (Freeman et al. 1995). Socioeconomic status at birth (I–V, with I assumed to be the most advantaged and V the least) was measured by paternal occupational social class at the time of the child's birth.

Measurement of adult socioeconomic position and lifestyle

Physical activity, social class, smoking status and history, alcohol consumption, achieved education and long-term illness history were derived from the responses to the self-completion questionnaire at age 49–51 years (Pearce et al. 2009). Physical activity was assessed using a questionnaire based on that used for the Medical Research Council's National Survey of Health and Development (Kuh and Cooper 1992) and activity split into four types: sport, occupational, commuting (walking and cycling) and household (housework, gardening and DIY). Three categories of activity levels were derived: inactive, less active and most active, further detailing of each level is outlined in Table 1. Occupational details of the main wage earner in the household were coded according to the 1990 UK Registrar General's Standard Occupational Classification from which social class was derived. The number of pack-years of cigarettes smoked (one pack-year = one pack of cigarettes smoked per day for 1 year) was estimated from reported smoking habits at ages 15, 25, 35 and 49–51 years. Smoking status at the time of questionnaire completion was also derived (never, ex-smoker, current smoker). Four categories of alcohol consumption at age 49–51 years were derived: no drinking; light drinking (up to 10 units/week of alcohol for males, 5 units for females); moderate drinking (11–28 units for males, 6–21 units for females); and heavy drinking (>28 units for males, >21 units for females (Power et al. 1998)). Four categories of achieved education level were derived (none; O-level; A-level; degree and postgraduate qualification). Having a long-term illness, health problem or disability, particularly in relation to limiting daily activities, was also self-reported. During physiological investigations, height and weight were measured and BMI derived. Percent body fat was estimated from impedance measured using a Holtain body composition analyser (Holtain Ltd., Crymych, Wales, UK). As the study included 168 study members who did not attend the physiological assessment, self-reported height and weight from the questionnaire at age 49–51 years were used for these participants.

Statistical analysis

Social class at birth and age 49–51 years, collapsed into most advantaged (I, II), middle (III) and least advantaged (IV, V), sex, presence of long-term illness, alcohol consumption, current smoking status and achieved education

Table 1 Criteria used to classify physical activity at age 49–51 years in the Newcastle Thousand Families Study

Type of physical activity	Most active	Less active	Inactive
Commuting activity (walking and cycling)	Walk or cycle 1 mile or more on an average weekday or weekend	Walk or cycle less than 1 mile on an average weekday or weekend	No distance walked or cycled during the week or weekend
Household activity (vigorous housework, gardening or DIY)	Regularly done at least once a week	Regularly done less than once a week	Does not take part in household activities
Sport activity (self-reported vigorous leisure activities)	Takes part in sport at least once a week	Takes part in sport less than once a week	Does not take part in sport
Occupational activity	Up to half the day or more of strenuous activities at work	Less than 2 h of strenuous activities at work	No strenuous activities at work or not in paid work

were treated as categorical variables (Table 2). All other explanatory variables were treated as continuous (Table 3). Representativeness of the participants in this study compared to those of the original cohort was assessed using χ^2 and t tests. A factor analysis with principal component extraction and Kaiser criterion (which suggests only retaining factors with eigenvalues greater than one) for factor retention of all four activity types reduced physical activity into two factors.

Associations between physical activity and explanatory variables were estimated by ordered logistic regression for the four categorical activity types. Odds ratios (OR) and corresponding 95 % confidence intervals (95 % CI) are reported. Interactions between explanatory variables were investigated at this stage.

Linear regression was used for the analysis of the two continuous factors derived from factor analysis.

To estimate the indirect pathways (i.e. non-independent predictors, which are mediated through other variables), adjusted linear regression models for the two continuous factors were reconstructed as path diagrams. Variables that were not in the adjusted multiple linear regression models (i.e. that were not independently predictive of the two factors) were then added to the path diagram, and all paths or correlations with $p < 0.1$ were modelled. The resulting model was reconstructed using the full data, with categorical variables being mapped onto a cumulative normal probability function. Model fit was assessed using model χ^2, goodness-of-fit index (GFI), comparative fit index (CFI) and root mean square error of approximation (RMSEA). Adequate fit was defined as a χ^2 p value greater than 0.05, GFI and CFI greater than 0.95, and RMSEA less than 0.05, all of which were satisfied.

In order to allow comparison between variables and estimate the relative importance, standardised beta coefficients (β) were derived for each explanatory variable (where a standardised coefficient is the standard deviation (SD) change in factor score elicited by a 1 SD change in the explanatory variable). Parameters were estimated using a random-walk Markov Chain Monte Carlo algorithm. Assuming diffuse uniform priors, the procedure was run for a burn-in sample of 1,000 observations, and an analysis sample of 100,000. 95 % credible intervals (CrIs), analogous to confidence intervals, were obtained from the posterior distribution of each parameter. The final convergence statistic for the model was 1.0001.

All factor and regression analyses were done using Stata, version 10 (Stata Corp., College Station, TX), while path analyses were done using AMOS 17.0 (SPSS Inc., Chicago, IL).

Results

Of the original cohort, 832 (86 % of the surviving sample of 967 children whose families remained in Newcastle for at least the first year of the study) were traced at age 49–51 years. Of these, 574 completed the health and lifestyle questionnaire. Those included in this analysis did not differ significantly from the remainder of the cohort for standardised birth weight ($p = 0.36$) or social class at birth ($p = 0.11$). However, differences were seen for sex ($p < 0.001$), with more women returning the questionnaire than men.

At age 49–51 years, over 50 % of both men and women in this cohort reported themselves to be inactive in sport and occupational activities, in contrast to the majority being highly active in household and commuting activities (Table 2). Univariate analyses with each measure of physical activity are shown in Table 4. Sex differences were seen in occupational and household activities with women having lower occupational activity and higher household activity than men (Table 4).

After adjustment, being in an advantaged social class, having a high education level or not being a smoker at age 49–51 years was associated with higher sport activity (Table 5). Smokers and those in the middle manual class had the highest occupational and commuting activity levels. Having a long-term illness reduced all activity types. There was a significant interaction between sex and long-

Table 2 Categorical summary for the included members of the Newcastle Thousand Families Study at age 49–51 years, by sex

Variable	Male		Female		Total	
	N	Percentage	*N*	Percentage	*N*	Percentage
Sex	216	45	261	55	477	100
Social class at birth[a]						
I, II	26	12	22	8	48	10
III	127	59	170	65	297	62
IV, V	63	29	69	27	132	28
Social class at age 49–51 years[a]						
I, II	103	49	130	52	233	51
III	81	39	84	34	165	36
IV, V	26	12	36	14	62	13
Alcohol consumption at age 49–51 years						
None	14	7	38	15	52	11
Light	87	40	111	42	198	42
Medium	86	40	102	39	188	39
Heavy	29	13	10	4	39	8
Smoking status at age 49–51 years						
Never	71	33	119	46	190	40
Ex	87	40	61	23	148	31
Current	58	27	81	31	139	29
Long-term illness						
No	135	62	174	67	309	65
Yes	81	38	87	33	168	35
Achieved education level						
None	62	29	110	42	172	36
O-level	65	30	88	34	153	32
A-level	52	24	36	14	88	19
Degree/postgraduate	37	17	27	10	64	13
Sport activity at age 49–51 years						
I	136	63	163	62	299	63
LA	23	11	17	7	40	8
MA	57	26	81	31	138	29
Work activity at age 49–51 years						
I	127	59	172	66	299	63
LA	49	23	77	29	126	26
MA	40	18	12	5	52	11
Household (housework, gardening and DIY) activity at age 49–51 years						
I	60	27	20	8	80	17
LA	41	19	31	12	72	15
MA	115	53	210	80	325	68
Commuting (walking and cycling) activity at age 49–51 years						
I	15	7	26	10	41	9
LA	86	40	111	43	197	41
MA	115	53	124	47	239	50

I inactive, *LA* least active, *MA* most active

[a] Most advantaged (I, II), middle (III), least advantaged (IV, V)

Table 3 Continuous descriptive statistics for the included members of the Newcastle Thousand Families Study at age 49–51 years, by sex

Variable	Male		Female		Total	
	N	Mean (SD)	*N*	Mean (SD)	*N*	Mean (SD)
Standardised birth weight	216	−0.25 (1.03)	261	0.03 (1.05)	477	−0.10 (1.05)
Body mass index age 49–51 years	216	26.66 (3.49)	261	25.94 (5.00)	477	26.27 (4.39)
Physical activity factor 1 score	216	−0.17 (1.01)	261	0.15 (0.99)	477	0.01 (1.01)
Physical activity factor 2 score	216	−0.06 (1.10)	261	0.01 (0.89)	477	−0.02 (0.99)
	N	Median (IQR)	*N*	Median (IQR)	*N*	Median (IQR)
Duration breast-fed (weeks)	164	10 (4, 32)	212	10 (4, 32)	376	10 (4, 32)
Gestational age (weeks)	216	40 (40, 40)	261	40 (40, 40)	477	40 (40, 40)
Cigarette smoking history[a]	216	10.9 (0, 28)	261	1.1 (0, 19)	477	4.3 (0, 23)

[a] Pack-years cigarettes, excluding 71 males and 119 females who had never smoked

term illness and sport activity ($p = 0.04$). In sex specific analyses, men with long-term illness had significantly lower sports activity than men without long-term illness (OR 0.39, 95 % CI 0.21, 0.72), whilst for women the impact of long-term illness was much less and non-significant reduction (OR 0.98, 95 % CI 0.57, 1.68). No significant associations were observed for other variables.

A two factor model, with two factors chosen under the Kasier criteria, was found to explain 62 % of the total variation between all physical activity types. The third and fourth, unselected factors contributed very little in terms of explaining the variance. Orthogonally rotated factor loadings were high in sport activity (0.87) for factor 1 (labelled PAF1) and high in occupational (0.64), household (0.64) and commuting (0.74) activities for factor 2 (labelled PAF2). Increasingly advantaged current social class and achieved education levels and being female were associated with higher PAF1 scores (Table 6). Lower scores were observed in both those who currently smoked and ex-smokers in comparison to those who had never smoked. More advantaged current social class and achieved education levels and having a long-term illness were associated with lower PAF2 scores. The interaction between sex and long-term illness on PAF1 scores had borderline significance ($p = 0.063$).

Figures 1 and 2 illustrate the adjusted models for PAF1 and PAF2, respectively, with indirect associations, in schematic form. The standardised direct effect of each significant association is shown, as well as the standardised total effect of each variable (i.e., including both the direct effect and indirect effects mediated through other variables). Social class at age 49–51 years had the largest total effect on PAF1 ($\beta = -0.27$, 95 % CrI −0.39, −0.14) and the second highest total effect on PAF2 ($\beta = 0.17$, 95 % CrI 0.04, 0.29). Long-term illness had the largest total effect on PAF2 ($\beta = -0.19$, 95 % CrI −0.28, −0.11). After current social class, smoking status ($\beta = -0.20$, 95 % CrI −0.30, −0.09), achieved education level ($\beta = 0.18$, 95 % CrI 0.08, 0.28), social class at birth ($\beta = -0.15$, 95 % CrI −0.21, −0.09) and sex ($\beta = 0.14$, 95 % CrI 0.05, 0.22) had similar total effects on PAF1. Achieved education level made the next highest contribution to PAF2 ($\beta = -0.13$, 95 % CrI −0.22, −0.03). Social class at birth was the only early life factor to have an indirect effect on both factor scores. This was mediated through current social class, current smoking status and achieved education level.

Excluding BMI, for which associations may be bi-directional, produced similar results. BMI and mediating pathways (i.e., those predicting BMI) are shown in white in Figs. 1 and 2. Assuming a one-directional effect of BMI, the relative contributions on PAF1 and PAF2 were −0.11 (95 % CrI −0.19, −0.02) and −0.15 (95 % CrI −0.23, −0.06), respectively.

Body mass index as used in the analyses was predominantly measured, but also included self-reported scores, where direct measurements were unavailable. Sensitivity analyses restricted to measured BMI produced identical associations, with estimated odds ratios and coefficients very similar to the analyses with combined BMI measurements. An 80 % reduction in sample size was incurred with restricted analyses, and a mean difference of 0.81 was found between comparable direct and self-reported measurements of BMI. Analyses using percent body fat (results not presented) showed similar results to that of measured BMI.

Discussion

Significant associations with physical activity levels were seen with social class, smoking and BMI at age 49–51 years, achieved education level and long-term illness. Of the early life and childhood factors considered, associations were present with social class at birth, but

Table 4 Univariate associations with all measures of physical activity at age 49–51 years in the Newcastle Thousand Families Study

Variables	Sport activity OR (95 % CI)	Occupational activity OR (95 % CI)	Household activity OR (95 % CI)	Commuting activity OR (95 % CI)	Physical activity factor 1 Co-eff (95 % CI)	Physical activity factor 2 Co-eff (95 % CI)
Sex						
Male	Reference	Reference*	Reference**	Reference	Reference**	Reference
Female	1.08 (0.77, 1.51)	0.59 (0.42, 0.83)	3.18 (2.21, 4.58)	0.79 (0.56, 1.09)	0.33 (0.16, 0.49)	0.04 (−0.13, 0.21)
Birth weight[a]	0.98 (0.84, 1.15)	1.01 (0.86, 1.19)	1.06 (0.90, 1.25)	1.00 (0.86, 1.16)	0.01 (−0.07, 0.09)	0.01 (−0.07, 0.08)
Gestational age	0.98 (0.84, 1.14)	1.01 (0.88, 1.16)	0.90 (0.76, 1.06)	0.82 (0.70, 0.95)*	−0.02 (−0.01, 0.01)	−0.08 (−0.15, −0.01)*
Duration breast-fed	1.00 (0.99, 1.00)	0.99 (0.99, 1.00)	1.00 (0.99, 1.00)	0.99 (0.99, 1.00)	0.00 (−0.01, 0.01)	0.00 (−0.01, 0.01)
Social class at birth[b]						
I, II	1.62 (0.95, 2.75)**	0.71 (0.39, 1.29)	0.62 (0.36, 1.07)	1.06 (0.63, 1.79)	0.22 (−0.06, 0.50)*	−0.15 (−0.43, 0.13)
III	Reference	Reference	Reference	Reference	Reference	Reference
IV, V	0.51 (0.34, 0.79)	1.31 (0.88, 1.92)	0.87 (0.58, 1.31)	1.22 (0.84, 1.77)	−0.31 (−0.51, −0.11)	0.09 (−0.11, 0.28)
Social class 1997[b]						
I, II	1.98 (1.34, 2.91)**	0.45 (0.30, 0.66)**	0.95 (0.63, 1.41)	0.66 (0.46, 0.96)*	0.45 (0.26, 0.64)	−0.30 (−0.49, −0.11)*
III	Reference	Reference	Reference	Reference	Reference	Reference
IV, V	0.47 (0.24, 0.90)	0.89 (0.53, 1.50)	1.33 (0.73, 2.40)	0.91 (0.54, 1.53)	−0.19 (−0.45, 0.08)	0.01 (−0.26, 0.27)
Body mass index	0.94 (0.8, 0.99)*	0.97 (0.93, 1.01)	0.95 (0.91, 0.99)*	0.98 (0.94, 1.02)	−0.02 (−0.05, −0.01)*	−0.03 (−0.05, −0.01)*
Alcohol consumption at age 49–51 years						
None	0.96 (0.53, 1.73)	0.76 (0.41, 1.40)	1.21 (0.66, 2.23)	0.76 (0.44, 1.29)	0.04 (−0.25, 0.32)	−0.06 (−0.34, 0.23)
Light	Reference	Reference	Reference	Reference	Reference	Reference
Medium	1.42 (0.98, 2.07)	1.24 (0.85, 1.80)	0.86 (0.58, 1.28)	0.76 (0.53, 1.09)	0.06 (−0.12, 0.26)	−0.04 (−0.23, 0.14)
Heavy	1.06 (0.56, 2.00)	1.48 (0.78, 2.81)	0.58 (0.32, 1.06)	0.81 (0.45, 1.49)	−0.13 (−0.45, 0.18)	−0.04 (−0.36, 0.28)
Smoking status at age 49–51 years						
Never	Reference**	Reference*	Reference	Reference	Reference**	Reference
Ex	0.73 (0.49, 1.07)	1.57 (1.04, 2.36)	0.71 (0.47, 1.06)	1.29 (0.88, 1.90)	−0.27 (−0.46, −0.07)	0.04 (−0.16, 0.24)
Current	0.28 (0.17, 0.43)	1.94 (1.27, 2.97)	1.03 (0.66, 1.59)	0.96 (0.65, 1.41)	−0.65 (−0.85, −0.46)	0.12 (−0.09, 0.32)
Achieved education level						
None	Reference**	Reference*	Reference	Reference	Reference**	Reference
O-level	2.39 (1.52, 3.75)	0.81 (0.53, 1.22)	0.62 (0.39, 0.98)	0.83 (0.56, 1.24)	0.28 (0.08, 0.49)	−0.20 (−0.41, 0.01)
A-level	1.87 (1.11, 3.14)	0.78 (0.48, 1.28)	0.53 (0.32, 0.88)	0.90 (0.56, 1.43)	0.20 (−0.04, 0.44)	−0.19 (−0.44, 0.05)
Degree/ postgraduate	4.74 (2.72, 8.25)	0.34 (0.18, 0.65)	0.50 (0.29, 0.89)	0.56 (0.33, 0.94)	0.71 (0.43, 0.98)	−0.49 (−0.78, −0.22)
Lifetime smoking	0.97 (0.95, 0.97)**	1.02 (1.01, 1.03)*	0.99 (0.98, 1.00)	1.00 (0.99, 1.00)	−0.02 (−0.02, −0.01)**	0.00 (−0.01, 0.01)
Long-term illness						
No	Reference*	Reference*	Reference*	Reference*	Reference	Reference**
Yes	0.70 (0.49, 0.99)	0.57 (0.39, 0.83)	0.63 (0.43, 0.90)	0.63 (0.45, 0.88)	−0.12 (−0.30, 0.06)	−0.37 (−0.54, −0.20)

* Significant at $p < 0.05$

** Significant at $p < 0.01$

[a] Standardised for sex and gestational age

[b] Most advantaged (I, II), middle (III), least advantaged (IV, V)

were mediated through socioeconomic status, smoking status and educational achievement at age 49–51 years. Of higher importance were variations in later life such as current socioeconomic status, smoking status and long-term illness. Sex differences were relevant to work- and household-related activities and the sports-dominated PAF1. There was an interaction between long-term illness and sex on sport activity.

Table 5 Results of adjusted logistic regression analyses showing odds ratios of significant associations on all activities at age 49–51 years in the Newcastle Thousand Families Study

Variable	Sport activity		Occupational activity		Household activity		Commuting activity	
	OR (95 % CI)	*p*	OR (95 % CI)	*p*	OR (95 % CI)	*p*	OR (95 % CI)	*p*
Sex								
Male	Reference	0.48	Reference	<0.01	Reference	<0.01		–
Female	0.85 (0.5, 1.4)		0.50 (0.4, 0.9)		3.37 (2.3, 4.9)		–	–
Body mass index at age 49–51 years	0.95 (0.8, 0.99)	0.02	–	–	0.96 (0.9, 1.0)	0.05	–	–
Social class at age 49–51 years[a]								
I, II	1.58 (0.9, 2.5)	<0.01	0.47 (0.3, 0.7)	<0.01	–	–	0.64 (0.4, 0.9)	0.04
III	Reference		Reference		–		Reference	
IV, V	0.69 (0.4, 1.4)		0.94 (0.5, 1.6)		–		0.97 (0.6, 1.6)	
Achieved education level								
None	Reference	0.03	–	–	–	–	–	–
O-level	1.74 (1.0, 2.9)		–		–		–	
A-level	1.25 (0.7, 2.3)		–		–		–	
Degree/post graduate	2.35 (1.2, 4.6)		–		–		–	
Smoking status at age 49–51 years								
Never	Reference	<0.01	Reference	0.01	–	–	–	–
Ex	0.89 (0.6, 1.4)		1.35 (0.9, 2.1)		–		–	
Current	0.38 (0.2, 0.6)		1.99 (1.3, 3.1)		–		–	
Long-term illness								
No	Reference	0.01	Reference	<0.01	Reference	0.01	Reference	0.01
Yes	0.44 (0.2, 0.8)		0.50 (0.4, 0.9)		0.62 (0.4, 0.9)		0.60 (0.4, 0.9)	

[a] Most advantaged (I, II), middle (III), least advantaged (IV, V)

No direct associations were found between early life and adult physical activity, consistent with existing literature (Mattocks et al. 2008; Gaysina et al. 2010). Although childhood and adolescence intervention can be effective (Sluijs et al. 2007), intervention in adulthood may also be effective.

It is well documented that those from lower socioeconomic groups participate in less leisure time physical activity (Droomers et al. 1998) and more time in sedentary behaviour than those in higher groups (Fairclough et al. 2009). Achieved education level was directly associated with, and a relatively important predictor of, both PAF1 and PAF2. Sustained exposure to the education environment has a positive effect on activity levels (Fairclough and Stratton 2005), particularly sports, and begins to build good habits that can be followed throughout life. However, the increase in sport activity adds to a decline in household and commuting activities. In general, those with higher achieved education tend to have occupations that require a higher level of non-manual skills, hence the reduced household activity among those with higher achieved education. A higher skilled occupation may come with a higher salary and the opportunity to own and use transport facilities, thus reducing the need for commuting. This may partly explain the inverse association between socioeconomic advantage and commuting.

Sex differences were seen for household and occupational activities as expected. Sex differences were also seen for PAF1 scores, but not PAF2. The latter is likely due to the combination of occupational, household and commuting activities that predominate PAF2.

Advantaged social class at age 49–51 years was found to increase sport activity (PAF1) and decrease 'other physical activity' (PAF2) types, particularly occupational and commuting. This is consistent with the results for achieved education level, as those with higher skills and pay tend to be in more advantaged social classes. Current smoking was associated with reduced sport activity and PAF1, consistent with existing literature (Blair et al. 1985). The issue of bidirectional associations is also relevant to smoking as smokers may be less active because they smoke, as well as a more general lifestyle association between smoking and lesser activity, even when healthy (Katainen 2010). Lifecourse smoking had a small contribution to PAF2 which was mediated through long-term illness that in turn may limit/hinder physical activity. Long-term illness may also have a bidirectional association, as it may result in a less active lifestyle, but likewise

Table 6 Results of adjusted linear regression analyses showing coefficients for two retained factor scores, physical activity factor 1 (PAF1) and physical activity factor 2 (PAF2) at age 49–51 years in the Newcastle Thousand Families Study

Variable	PAF1		PAF2	
	β (95 % CI)	p	β (95 % CI)	p
Sex				
Male	Reference	<0.01	–	–
Female	0.31 (0.1, 0.5)		–	
Social class at age 49–51 years[a]				
I, II	0.34 (0.1, 0.5)	<0.01	−0.27 (−0.2, 0.1)	<0.01
III	Reference		Reference	
IV, V	−0.09 (−0.4, 0.2)		0.03 (−0.2, 0.3)	
Achieved education level				
None	Reference	0.05	Reference	0.04
O-level	0.10 (−0.1, 0.3)		−0.20 (−0.4, 0.0)	
A-level	−0.03 (−0.3, 0.2)		−0.01 (−0.3, 0.3)	
Degree or postgraduate	0.36 (0.1, 0.7)		−0.36 (−0.7, −0.1)	
Smoking status at age 49–51 years				
Never	Reference	<0.01	–	–
Ex	−0.10 (−0.3, 0.1)		–	
Current	−0.50 (−0.7, −0.3)		–	
Body mass index at age 49 51 years	−0.02 (−0.04, 0)	0.02	−0.04 (−0.1, −0.2)	<0.01
Long-term illness				
No	–	–	Reference	<0.01
Yes	–		−0.36 (−0.5, −0.2)	

[a] Most advantaged (I, II), middle (III), least advantaged (IV, V)

having a less active lifestyle may contribute to an increased risk of illness. The interaction between sex and long-term illness showed that males with long-term illness were less likely to participate in sports-related activities compared to females with long-term illnesses.

Adult social class was a better predictor of physical activity than social class measured in childhood. Adult social class reflects the individual, rather than in childhood where social class is assigned from their parents. Adult social class and upward social mobility are linked to education (Forrest et al. 2011) which may reflect why individuals in more advantaged classes exercise more, but this can also be influenced by factors such as finance and amount of free time, both of which are linked to ability to exercise. Adult social class is also bidirectionally associated with the presence of a long-term limiting illness, but also less limiting conditions that may still impact on physical activity. So, part of the social class association may reflect physical limitations that prevent or limit the amount of physical activity.

The results of our factor analysis suggest that, rather than considering many different types of activity, daily activities such as housework, commuting and occupational activity can be combined when investigating health outcomes, whereas sports type of leisure activity should be explored separately.

The study sample, 50 % of the surviving cohort members at age 49–51 years, was comparable for all explanatory variables in early life included in this investigation, except for sex. In addition, inclusion of cohort members who had moved out of the study region increased the representativeness of the population studied. The validity of self-reported questionnaire data as opposed to an objective measure such as an accelerometer can be questioned. It would be useful for a future study to replicate our analysis, but using a more objective measure of physical activity. While BMI was mostly from direct assessment, for those participants who did not attend, self-reported heights and weights were used to calculate BMI. Although there was an average underestimate of BMI from self-report, sensitivity analyses suggested little impact of this. Percent body fat could only be assessed in those who attended the physiological assessment, but gave similar results to that of measured BMI. The decision to use BMI was taken to increase the sample size and statistical power available.

The use of path analysis has several benefits over standard linear regression, including a more illustrative

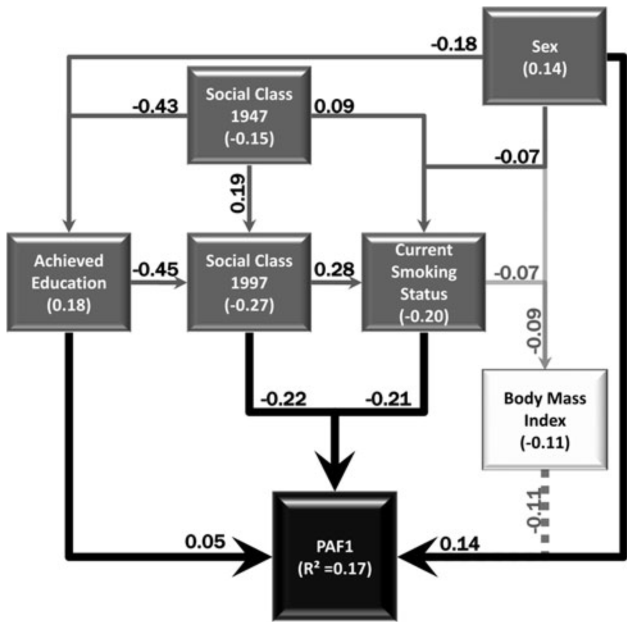

Fig. 1 Path diagram showing the direct and indirect predictors of physical activity factor 1 (PAF1) at age 49–51 years in the Newcastle Thousand Families Study. Significant effects ($p < 0.05$) are represented by *solid arrows* and are labelled with standardised coefficients (β), with the arrow direction indicating the hypothesised direction of causal flow. Indirect effects (*thin arrows*) are any pathways that are mediated through at least one intermediate (e.g., social class 1947 ≥ achieved education ≥ PAF1). Direct effects are represented by *thick arrows* going straight from the independent variable to PAF1 without being mediated through another independent variable. The standardised total effect for each variable is the sum of the direct and indirect effects, and the value is shown underneath the variable name. Variables in *white boxes* with *dashed arrows* show pathways when BMI is included in analysis. Error terms and co-variances are omitted for simplicity

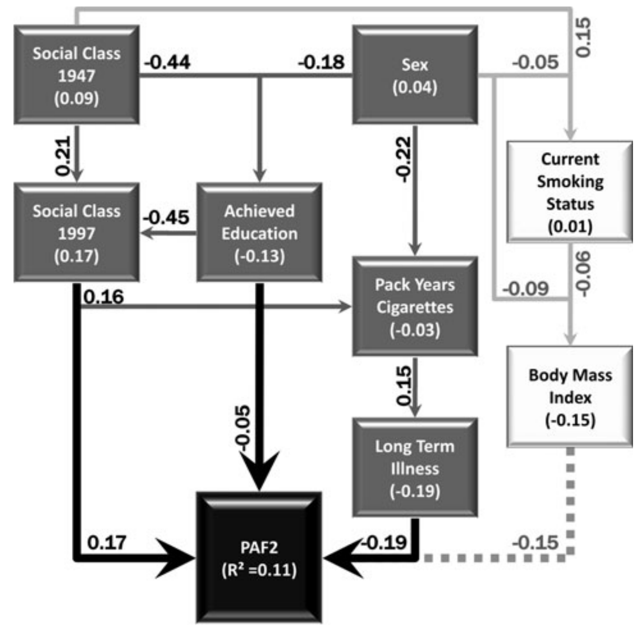

Fig. 2 Path diagram showing the direct and indirect predictors of physical activity factor 2 (PAF2) at age 49–51 years in the Newcastle Thousand Families Study. See Fig. 1 caption for explanation

quantification of the different pathways of influence. This study also builds on previous applications of path analysis in this cohort (Tennant et al. 2008; Mann et al. 2011), by modelling completely indirect variables, such as social class. Nevertheless, some limitations require consideration. Firstly, the direction of each relationship has to be inferred by the researcher. Finally, path analysis is sensitive to error, since the standard deviation of each estimate strongly contributes to the final effect size. However, as the majority of data for this study were collected prospectively, sources of error usually associated with retrospective data collection were minimised.

Conclusion

In this study, physical activity was reduced to 'sports' and 'other activities'. This may imply that, to improve the effectiveness of interventions, while all activity should be seen as good, interventions may apply differently to different types of activity. Our findings suggest that prolonged education environments have a positive effect on activity levels in adulthood, in particular sport activities combined with more advantaged social class status. Lifestyle interventions such as reducing smoking are important to increase activity levels, as well as reducing the related health problems. There are significant reductions in physical activity, especially in those who are less affluent, less well educated and who have impaired health. Increasing activity in adults requires better understanding what the barriers to maintaining or taking on new levels of physical activity are, and long-term strategies and public health interventions need to be developed to engage adults in interesting, affordable and available activities.

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Conflict of interest The authors declare that they have no conflict of interest.

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