Early Life Factors and Adult Leisure Time Physical Inactivity Stability and Change

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ABSTRACT

PINTO PEREIRA, S. M., L. LI, and C. POWER. Early Life Factors and Adult Leisure Time Physical Inactivity Stability and Change. *Med. Sci. Sports Exerc.*, Vol. 47, No. 9, pp. 1841–1848, 2015. **Purpose**: Physical inactivity has a high prevalence and associated disease burden. A better understanding of influences on sustaining and changing inactive lifestyles is needed. We aimed to establish whether leisure time inactivity was stable in midadulthood and whether early life factors were associated with inactivity patterns. **Methods**: In the 1958 British birth cohort (n = 12,271), leisure time inactivity (frequency, less than once a week) assessed at 33 and 50 yr was categorized as "never inactive," "persistently inactive," "deteriorating," or "improving." Early life factors (birth to 16 yr) were categorized into three (physical, social, and behavioral) domains. Using multinomial logistic regression, we assessed associations with inactivity persistence and change of factors within each early life domain and the three domains combined with and without adjustment for adult factors. **Results**: Inactivity prevalence was similar at 33 and 50 yr (approximately 31%), but 17% deteriorated and 18% improved with age. In models adjusted for all domains simultaneously, factors associated with inactivity persistence versus never inactive were prepubertal stature (8% lower risk/height SD), poor hand control/coordination (17% higher risk/increase on four-point scale), cognition (16% lower/SD in ability) (physical); parental divorce (25% higher), class at birth (7% higher/reduction on four-point scale), minimal parental education (16% higher), household amenities (2% higher/increase in 19-point score (high = poor)) (social); and inactivity (22% higher/reduction in activity on four-point scale), low sports aptitude (47% higher), smoking (30% higher) (behavioral). All except stature, parental education, sports aptitude, and smoking were associated also with inactivity deterioration. Poor hand control/coordination was the only factor associated with improved status (13% lower/increase on four-point scale) versus persistently inactive. **Conclusions**: Adult leisure time inactivity is moderately stable. Early life factors are associated with persistent and deteriorating inactivity over decades in midadulthood but rarely with improvement. **Key Words:** LEISURE TIME PHYSICAL INACTIVITY, LIFE COURSE, COHORT STUDY, BRITAIN

EPIDEMIOLOGY

Physical inactivity is a prevalent behavior (9) with high avoidable health costs (3,20,39). Inactivity is associated with all-cause mortality and elevated cardiovascular deaths, of 32% and 43% in men and women respectively, compared with the highly active (3,39). Inactivity is modifiable, and positive sustained behavior change could lead to reduced burden of disease. Preventing inactivity is particularly important, given the evidence suggesting that even low activity levels (i.e., the avoidance of inactivity) protects against mortality (21). Most prospectively identified exposures associated with (in)activity patterns in adulthood tend to be of adult factors (2,26,34,41), with studies paying little attention to factors from earlier life that may represent the origins from which influences on later inactivity evolve. Acknowledging the potential for earlier life factors to program later health and associated behaviors, we argued previously that life course processes may be relevant to adult (in)activity (27). For example, childhood adversities could lead to poor emotional adjustment (6), which in turn may lead to the uptake of hazardous lifestyles such as inactivity. We showed that early life physical (e.g., hand control/coordination problems), social (e.g., class at birth), and behavioral (e.g., sociability) factors were associated with adult leisure time inactivity, 33–50 yr, even after accounting for several key potential influences in adulthood (27). However, change in activity behavior over time is common within individuals, as suggested by low-to-moderate tracking of (in)activity observed in several populations (24,26,38) but we have yet to investigate whether early life factors are associated with persistence or change in adult inactivity. We might expect, for example, early life factors such as limited childhood physical capacities to be associated in particular with later inactivity persistence. A clearer understanding of the timing and nature of influences on sustaining inactive lifestyles and changing to or from inactivity could inform policies designed to tackle inactive lifestyles.

Using a nationwide general population sample followed from birth, our overall aim was to shed light on early life influences on leisure time inactivity persistence and change in adulthood from 33 to 50 yr. Our specific objectives were to (a) assess the extent to which inactivity was stable from 33 to 50 yr and (b) examine associations with inactivity persistence and change, 33–50 yr, of the following: (i) factors within three early life domains (physical, social, and

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behavioral), separately and combined, and (ii) the three domains combined with and without adjustment for adult factors, such as social class and physical limiting illness.

METHODS

The 1958 British Birth Cohort is an ongoing longitudinal study of all born during 1 wk in March 1958 across Britain (n = 17,638) and a further 920 immigrants with the same birth week (28). Information was collected in childhood (birth and 7, 11, and 16 yr) and adulthood (23, 33, 42, 45, and 50 yr). Ethical approval was given by the London Multicentre Research Ethics Committee, and an informed consent was obtained from participants at various ages, including 50 yr. Respondents in midadulthood are broadly representative of the total surviving cohort (1). The sample for this study consists of cohort members with information on inactivity at either 33 or 50 yr, who at 50 yr, were alive and living in Britain (n = 12,271).

Physical inactivity at 33 and 50 yr was measured by asking participants about regular leisure time activity frequency with a list of examples (e.g., swimming and going for walks) to aid recall and with "regular" defined as participation at least once a month for most of the year. Those responding affirmatively were asked about how often they were active, i.e., with three categories more frequent than once a week, once a week, and two categories ("2–3 times a month" and "less often") less than once a week (25). Consistent with previous work by us (27) and others (3,12,39), low activity was identified as participation less than once a week, hereafter referred to as inactivity. From binary inactivity measures at 33 and 50 yr, we identified four physical inactivity stability and change groups: (i) "never inactive" (≥1 per week at 33 and 50 yr) (ii) "persistently inactive" (active <1 per week at both ages) and two change groups, (iii) deteriorating status (≥1 per week at 33 yr and <1 per week at 50 yr), and (iv) improving status (<1 per week at 33 yr and ≥1 per week at 50 yr). Thus, deteriorating status refers to deterioration in activity (i.e., changing to inactivity) whereas improving status refers to an improvement in activity (i.e., changing from inactivity).

Early life factors were identified from previous studies of adolescent activity (7,10,11,17,23,40) or adolescent covariates for adult (in)activity (18,37). Most potential factors were assessed prospectively from birth to 16 yr and categorized into three broad domains (physical, social, and behavioral). Table 1 gives details for potential early life factors that correspond to those identified in our previous study, except that we omitted here factors unrelated to adult inactivity (i.e., low birth weight, birth order, paternal body mass index (BMI), pubertal timing, overweight or obese, maternal employment, childhood abuse, or sleep problems) (27).

Adult covariates at 33 yr include social class (four categories; as for class at birth, see Table 1), education (five categories, none to degree level), measured BMI, number of children in household (range, 0–8), physically limiting illness, and the psychological items of the malaise inventory (32).

Statistical analysis. All continuous early life factors (maternal BMI, maternal age, prepubertal stature, cognitive ability, internalizing behaviors (i.e., emotional problems), and externalizing behaviors (i.e., conduct problems)) were converted to internally standardized z-scores (mean, 0; SD, 1) to facilitate comparisons of their associations with inactivity patterns. For our first aim, to assess the extent to which inactivity was stable from 33 yr to 50 yr, we tabulated the four categories of inactivity stability and change. For our second aim, to determine associations of early life factors with adult inactivity patterns, we compared the (i) persistently inactive relative to the never inactive (i.e., the most vs the least adverse behavior, 33–50 yr), (ii) those with deteriorating status relative to the never inactive, and (iii) those with improving status relative to the persistently inactive (i.e., those changing inactivity status vs those remaining the same over the age range). We assessed factors associated with the four-category inactivity variable using multinomial logistic regression. First, we estimated relative risk ratios (RRR) and 95% confidence intervals (CI) for persistent inactivity or a deteriorating status relative to the never inactive (as the baseline). Initially, early life factors were examined separately; we then built three domain-specific (physical, social, and behavioral) multivariable models including all factors (from each domain) in one model. Second, to assess associations for the early life domains simultaneously, we combined all factors associated with inactivity patterns in the first stage of analysis into one model. Third, to examine whether the influence of early life factors was independent of adult factors, we adjusted for the adult covariates described previously. To assess associations of early life factors with improving status, we repeated the three-stage analysis described previously using the persistently inactive as the baseline.

Gender differences in associations between early life factors and inactivity were examined using an interaction term (gender–factor). There was little evidence of effect modification; hence, genders were combined in all analyses. Missing data ranged from 1% (internalizing and externalizing behaviors) to 37% (physical handicap/disabling condition). To minimize data loss, missing data were imputed using multiple imputation chained equations; imputation models included all model variables, including previously identified key predictors of missingness (1). Regression analyses were run across 10 imputed data sets. Imputed results were broadly similar to those using observed values; the former are presented here. All analyses were conducted using STATA version 12.1.

RESULTS

The prevalence of inactivity was similar at 33 yr (31.5%) and 50 yr (30.9%). However, there were changes within

TABLE 1. Early life factors (birth to 16 yr) in the 1958 birth cohort.

Early Life Factor	Ascertainment Method (Age)	Description	Categories/Units	*n* (%) or Mean (SD)
Physical domain				
Maternal pregnancy smoking[a]	Parental report (0 yr)	≥1 cigarette per day after fourth month of pregnancy	Yes or no	Yes, 3791 (33.0)
Maternal 1958 BMI	Parental report (0 yr)	Weight (kg) /height (m)^2	Continuous[b]	22.91 (3.44) kg·m^{-2}
Maternal age	Parental report (0 yr)	Age (yr) in 1958	Continuous[b]	27.54 (5.70) yr
Prepubertal stature	Measured (7 yr)	Height (cm) measured using standardized protocols	Continuous[b]	122.4 (5.9) cm
Cognitive ability	Reading and mathematics tests (13) (16 yr)	Derived age-standardized score for each test, converted to 0–100 scale. Average of two tests was used (if missing, corresponding average from 11 yr or 7 yr was used).	Continuous[b]	NA
Physical handicap/disabling condition	Parental report (7 and 16 yr)	Physical handicap/disabling condition at 7 yr and/or 16 yr	Yes or no	Yes, 904 (11.8)
Hand control/coordination problems	Teacher rating (7, 11, and 16 yr)	At each age recorded as follows: no problems (score, 0) and somewhat or certainly applies (score, 1). Summed across ages.	Number of ages: 0, 1, 2, and 3	0, 3961 (57.2) 1, 1893 (27.3) 2, 798 (11.5) 3, 273 (3.9)
Social domain				
Social class	Parental report (birth)	Father's occupation at birth (or if missing at 7 yr). Categorized according to Registrar General's (1951) Classification.	1. Professional/managerial 2. Skilled non-manual 3. Skilled manual 4. Semiskilled/unskilled/ single parent household	1, 2141 (18.0) 2, 1171 (9.9) 3, 5817 (48.9) 4, 2760 (23.2)
Parental divorce	Self-report (33 yr)		Yes or no	Yes, 1672 (15.4)
Minimal parental education	Parental report (0 and 7 yr)	Both parents had minimal schooling	Yes or no	Yes, 6334 (60.1)
Childhood neglect	Parental and teacher report (7 and 11 yr)	≥2 of five items at 7 yr and/or 11 yr (teacher report of child's physical appearance, parent report of involvement with child)	Yes or no	Yes, 2123 (18.7)
Household amenities	Parental report (7, 11, and 16 yr)	Availability of bathroom, indoor lavatory, or hot water. Reported as: sole use (0), shared (1), or not available (2). Composite score 7–16 yr was derived.	Score, 0–18 (higher scores indicate limited access)	1.08 (2.7)
Institutional care	Parental/guardian report (7, 11, and 16 yr)	Ever in institutional care by 16 yr	Yes or no	Yes, 470 (6.3)
Behavioral domain				
Physical activity	Self-report (16 yr)	Participants were asked how often they (1) played outdoor and (2) indoor games and sports or (3) went swimming or (4) dancing. Responses were often (2), sometimes (1), or never (0). Scores summed across variables; collapsed to four categories (25).	1. Most active 2. Very active 3. Active 4. Least active	1, 1759 (19.1) 2, 1365 (14.8) 3, 1769 (19.2) 4, 4324 (46.9)
Sports aptitude (less than or equal to average)	Self-report (16 yr)		Yes or no	Yes, 6754 (73.9)
Dissatisfaction with nearby sporting facilities	Self-report (16 yr)		Yes or no	Yes, 5151 (56.4)
Internalizing behaviors (emotional problems)	Teacher rating (16 yr)	Using five of the 26-item Rutter behavior scale. Categorized as follows: applies (2), somewhat (1), or does not apply (0). Scores summed across items (if missing measures from 11 or 7 yr were used) (30).	Continuous[b]	NA
Externalizing behaviors (conduct problems)	Teacher rating (16 yr)	Using nine items from the Rutter behavior scale (as mentioned); scores summed (if missing measures from 11 or 7 yr were used) (30).	Continuous[b]	NA
Sociability	Teacher rating (16 yr)		Five categories: sociable to withdrawn	1 (sociable), 2209 (23.5) 2, 3189 (33.9) 3, 2553 (27.1) 4, 1310 (13.9) 5 (withdrawn), 151 (1.6)
Smoking	Self-report (16 yr)		Yes or no	Yes, 3234 (35.2)
Alcohol consumption in last week	Self-report (16 yr)	Number and type of drinks consumed in past week: pints of beer, glasses of wine, measures of spirits. Alcohol amount coded as standard units; categorized into four groups (14).	1, 7+ units 2, 3–6 units 3, 0–2 units 4, none	1, 992 (10.8) 2, 1,359 (14.7) 3, 1,988 (21.6) 4, 4,887 (53.0)

n varies because of missing data.
Low birth weight, birth order, paternal BMI, pubertal timing, overweight or obese, maternal employment, childhood abuse, and sleep problems were shown previously to be unrelated to adult inactivity (27) and hence are not included here.
[a]Maternal smoking in pregnancy was included as a physical factor because of its association with offspring physical characteristics (such as neurological deficits) (19).
[b]Converted to internally standardized *z*-scores (mean, 0; SD, 1) for analysis (see Methods for details).
NA, nonstandardized values are not available because measures for the combination of ages are not meaningful.

individuals as they age, as follows: 35% changed their inactivity status, with roughly equal proportions deteriorating (17%) and improving (18%), 14% were persistently (33 and 50 yr) inactive, and the remainder (52%) were never inactive (see Table 2 footnote).

Univariable and Multivariable Domain-Specific Associations

Early life physical factors. All factors except maternal age were associated with persistent inactivity versus the never inactive (Table 2 column 1). All factors except physical handicap/disabling condition, maternal age, and smoking were related to deteriorating status versus the never inactive (Table 2 column 2), whereas only poor hand control/coordination and higher 16-yr cognition were associated with improving status versus persistent inactivity (Table 2 column 3). In multivariable analyses (i.e., including all factors from the physical domain), higher maternal BMI was associated with elevated RRR of persistent inactivity whereas shorter prepubertal stature, poor hand control/coordination, and poor cognition were associated with elevated risk of persistent inactivity and also with deteriorating status. The only factor associated with improving status was poor hand control/coordination.

Early life social factors. More adverse early life social backgrounds were associated with inactivity persistence or deterioration compared with the never inactive, and all associations remained, although attenuated, in multivariable analyses (Table 2). Minimal parental education, childhood neglect, institutional care, and poor amenities were associated with a lower RRR of improving status (relative to the persistently inactive), but in multivariable analysis, i.e., when all factors from the social domain were considered simultaneously, the only association to remain was for institutional care.

Early life behavioral factors. Most examined factors were associated with either persistent inactivity or deteriorating status versus the never inactive (Table 2). In domain-specific multivariable analyses, lower 16-yr activity, internalizing and externalizing problems were associated with increased RRR of persistent inactivity or deteriorating status, and in addition, smoking, lower alcohol consumption, and low sports aptitude were associated with elevated RRR of persistent inactivity. Although lower 16-yr activity, internalizing and externalizing behaviors were associated with lower RRR of improving status compared with persistent inactivity, in multivariable analysis, the only factor to remain was externalizing behaviors.

Associations for Combined Domains and with Adjustment for Adult Factors

In models that accounted for all domains simultaneously, factors from the physical, social, and behavioral domains were associated with inactivity persistence and deterioration compared with the never inactive (Table 3). Poorer hand control/coordination, lower 16-yr cognition, lower class background, parental divorce, poorer household amenities, and lower 16-yr activity were associated with elevated

TABLE 2. RRR (95% CI) of adult physical inactivity[a] persistence and change[b], 33–50 yr, for early life factors, estimated from domain-specific univariable and multivariable models (n = 12,271).

	Univariate Models			Multivariable Models[c]		
	Persistently Inactive vs Never Inactive	Deteriorating vs Never Inactive	Improving vs Persistently Inactive	Persistently Inactive vs Never Inactive	Deteriorating vs Never Inactive	Improving vs Persistently Inactive
Physical domain[d]						
Prepubertal stature[e]	0.84 (0.79–0.90)	0.89 (0.83–0.94)	1.07 (0.99–1.15)	0.90 (0.84–0.96)	0.93 (0.87–0.99)	1.05 (0.97–1.13)
Hand control/coordination problems[f]	1.41 (1.31–1.53)	1.26 (1.15–1.37)	0.82 (0.76–0.89)	1.27 (1.17–1.39)	1.16 (1.05–1.28)	0.84 (0.77–0.92)
16 yr cognition[e]	0.69 (0.65–0.73)	0.76 (0.72–0.81)	1.14 (1.06–1.23)	0.77 (0.72–0.82)	0.81 (0.75–0.86)	1.08 (0.99–1.17)
Physical handicap/disabling condition[g]	1.26 (1.03–1.55)	1.20 (0.95–1.52)	0.96 (0.74–1.24)	0.97 (0.78–1.22)	1.01 (0.80–1.29)	1.10 (0.84–1.43)
Maternal smoking in pregnancy[g]	1.23 (1.09–1.39)	1.10 (0.97–1.26)	0.94 (0.79–1.11)	1.10 (0.97–1.25)	1.02 (0.89–1.16)	0.97 (0.82–1.16)
Maternal 1958 BMI[e]	1.09 (1.02–1.15)	1.06 (1.002–1.12)	0.95 (0.89–1.02)	1.07 (1.004–1.13)	1.05 (0.99–1.11)	0.96 (0.89–1.03)
Social domain						
Social class at birth (high–low)[f]	1.27 (1.19–1.35)	1.25 (1.17–1.33)	0.88 (0.81–0.95)	1.14 (1.06–1.22)	1.15 (1.08–1.23)	0.93 (0.86–1.02)
Minimal parental education[g]	1.57 (1.39–1.78)	1.45 (1.28–1.65)	0.80 (0.68–0.93)	1.30 (1.14–1.49)	1.23 (1.07–1.42)	0.87 (0.74–1.03)
Childhood neglect[g]	1.65 (1.37–1.99)	1.42 (1.22–1.64)	0.78 (0.65–0.93)	1.35 (1.11–1.64)	1.18 (1.01–1.37)	0.87 (0.73–1.04)
Parental divorce[g]	1.42 (1.20–1.69)	1.37 (1.18–1.60)	0.82 (0.67–1.02)	1.30 (1.09–1.55)	1.29 (1.10–1.50)	0.87 (0.70–1.08)
Institutional care[g]	1.90 (1.47–2.46)	1.66 (1.28–2.13)	0.59 (0.42–0.82)	1.51 (1.16–1.96)	1.36 (1.04–1.77)	0.66 (0.47–0.92)
Household amenities[f]	1.05 (1.03–1.07)	1.05 (1.03–1.06)	0.98 (0.96–0.9999)	1.03 (1.01–1.05)	1.03 (1.01–1.04)	0.99 (0.97–1.01)
Behavioral domain						
16 yr activity (most–low)[f]	1.28 (1.20–1.35)	1.07 (1.02–1.12)	0.92 (0.86–0.99)	1.20 (1.13–1.28)	1.06 (1.005–1.11)	0.93 (0.86–1.01)
16 yr sports aptitude (less than or equal to average)[g]	1.85 (1.58–2.17)	1.18 (1.02–1.37)	0.87 (0.72–1.04)	1.51 (1.27–1.80)	1.12 (0.95–1.31)	0.92 (0.76–1.13)
16 yr dissatisfaction with sporting facilities[g]	1.16 (1.01–1.33)	0.93 (0.80–1.09)	0.95 (0.80–1.14)	1.06 (0.92–1.22)	0.90 (0.77–1.06)	0.98 (0.82–1.17)
16 yr internalizing behavior[e]	1.24 (1.17–1.30)	1.15 (1.09–1.21)	0.93 (0.87–0.998)	1.11 (1.04–1.18)	1.08 (1.02–1.15)	0.98 (0.90–1.06)
16 yr externalizing behavior[e]	1.22 (1.15–1.29)	1.17 (1.11–1.23)	0.89 (0.83–0.96)	1.15 (1.09–1.23)	1.13 (1.07–1.19)	0.90 (0.83–0.98)
16 yr sociability (sociable–withdrawn)[f]	1.18 (1.11–1.26)	1.11 (1.05–1.17)	0.94 (0.87–1.03)	1.05 (0.97–1.13)	1.04 (0.983–1.11)	0.99 (0.89–1.09)
16 yr smoking[g]	1.48 (1.24–1.75)	1.21 (1.05–1.38)	0.84 (0.70–1.02)	1.44 (1.20–1.72)	1.13 (0.97–1.32)	0.89 (0.73–1.08)
16 yr alcohol consumption in last week (7+ units–none)[f]	1.08 (0.997–1.17)	1.01 (0.94–1.08)	1.00 (0.92–1.08)	1.09 (1.004–1.19)	1.01 (0.94–1.09)	0.98 (0.90–1.07)

Analysis adjusted for gender.
[a]Averaged over ten imputed data sets. n (%) inactive at 33 yr, 3863 (31.5); at 50 yr, 3791 (30.9). n (%) inactive 33–50 yr, never inactive, 6316 (51.5); persistently inactive, 1699 (13.8); deteriorating, 2093 (17.1); and improving, 2164 (17.6).
[b]Comparisons are 1) persistently inactive relative to the never inactive (i.e., the most vs the least adverse behavior 33–50 yr), 2) those with deteriorating status relative to the never inactive, and 3) those with improving status relative to the persistently inactive (i.e., those changing inactivity status vs those remaining the same over the age range).
[c]Multivariable models mutually adjust for all factors from the same domain.
[d]There was no relation between maternal age at birth and physical inactivity patterns; therefore, associations are not shown.
[e]Per SD increase.
[f]Per increase in scale.
[g]Attribute vs nonattribute.

TABLE 3. RRR (95% CI) of physical inactivity persistence and change[a] 33–50 yr for early life factors in all (physical, social, and behavioral) domains combined.

	Persistently Inactive vs Never Inactive	Deteriorating vs Never Inactive	Improving Vs Persistently Inactive
	Physical domain		
Prepubertal stature[b]	0.92 (0.86–0.98)	0.94 (0.89–1.004)	1.04 (0.96–1.12)
Hand control/coordination problems[c]	1.17 (1.07–1.28)	1.12 (1.004–1.25)	0.87 (0.79–0.95)
16 yr cognition[b]	0.84 (0.78–0.91)	0.88 (0.82–0.94)	1.00 (0.91–1.10)
Maternal 1958 BMI[b]	1.05 (0.99–1.12)	1.04 (0.98–1.10)	0.96 (0.90–1.03)
	Social domain		
Social class at birth (high–low)[c]	1.07 (1.003–1.15)	1.11 (1.04–1.19)	0.95 (0.87–1.03)
Minimal parental education¥	1.16 (1.01–1.33)	1.13 (0.98–1.31)	0.90 (0.76–1.06)
Childhood neglect[d]	1.06 (0.86–1.32)	1.00 (0.85–1.18)	0.95 (0.78–1.15)
Parental divorce[d]	1.25 (1.04–1.49)	1.25 (1.07–1.46)	0.88 (0.71–1.09)
Institutional care[d]	1.27 (0.97–1.66)	1.22 (0.93–1.61)	0.71 (0.51–1.002)
Household amenities[c]	1.02 (1.002–1.04)	1.02 (1.003–1.04)	0.99 (0.97–1.02)
	Behavioral domain		
16 yr activity (most–low)[c]	1.22 (1.14–1.29)	1.06 (1.01–1.11)	0.93 (0.86–1.01)
16 yr sports aptitude (less than or equal to average)[d]	1.47 (1.24–1.75)	1.09 (0.92–1.28)	0.95 (0.78–1.16)
16 yr internalizing behavior[b]	1.04 (0.98–1.11)	1.03 (0.97–1.09)	1.01 (0.94–1.10)
16 yr externalizing behavior[b]	1.06 (0.99–1.13)	1.05 (0.99–1.12)	0.94 (0.86–1.02)
16 yr smoking[d]	1.30 (1.08–1.57)	1.05 (0.90–1.22)	0.92 (0.75–1.12)
16 yr alcohol consumption in last week (7+ units–none)[c]	1.03 (0.95–1.13)	0.97 (0.90–1.05)	1.01 (0.93–1.10)

Analysis is adjusted for gender and all factors in the table.
[a]Comparisons are 1) persistently inactive relative to the never inactive (i.e., the most vs the least adverse behavior 33–50 yr), 2) those with deteriorating status relative to the never inactive, and 3) those with improving status relative to the persistently inactive (i.e., those changing inactivity status vs those remaining the same over the age range).
[b]Per SD increase.
[c]Per increase in scale.
[d]Attribute vs nonattribute.

RRR of persistent inactivity or deteriorating status. For example, for those with divorced parents, the RRR of being persistently inactive or deteriorating were 1.25 (95% CI, 1.04–1.49) and 1.25 (95% CI, 1.07–1.46), respectively. RRR of persistent inactivity and deterioration for those in institutional care were of similar magnitude (1.27 and 1.22, respectively, but CI included 1). Additional associations with persistent inactivity were observed for shorter prepubertal stature, minimal parental education, low sports aptitude, and smoking, and an association between shorter prepubertal stature and deteriorating status was borderline, as follows: RRR, 0.94 (95% CI, 0.89–1.004). Poor hand control/coordination was the only factor that differentiated between improving and persistent inactivity (RRR, 0.87 (95% CI, 0.79–0.95)), although there was a borderline association for those in institutional care being less likely to be improvers. After adjusting for adult covariates (Table 4), several associations of early life factors with adult inactivity persistence, deterioration, and improvement remained largely undiminished (e.g., for prepubertal stature, 16-yr activity, and sports aptitude). An exception was the weakened to

EPIDEMIOLOGY

TABLE 4. RRR (95% CI) of physical inactivity persistence and change[a] 33–50 yr for early life factors in all (physical, social, and behavioral) domains combined, with adjustment for adult factors.[b]

	Persistently Inactive vs Never Inactive	Deteriorating vs Never Inactive	Improving vs Persistently Inactive
	Physical domain		
Prepubertal stature[c]	0.92 (0.86–0.98)	0.94 (0.88–0.999)	1.05 (0.98–1.13)
Hand control/coordination problems[d]	1.11 (1.01–1.21)	1.08 (0.96–1.21)	0.90 (0.82–0.99)
16 yr cognition[c]	0.99 (0.90–1.08)	0.99 (0.91–1.08)	0.94 (0.83–1.05)
Maternal 1958 BMI[c]	1.03 (0.96–1.09)	1.02 (0.96–1.08)	0.98 (0.92–1.05)
	Social domain		
Social class at birth (high–low)[d]	1.04 (0.97–1.12)	1.09 (1.01–1.16)	0.96 (0.88–1.05)
Minimal parental education[e]	1.08 (0.94–1.24)	1.07 (0.92–1.24)	0.93 (0.79–1.10)
Childhood neglect[e]	1.00 (0.81–1.24)	0.96 (0.82–1.12)	0.96 (0.79–1.17)
Parental divorce[e]	1.19 (0.99–1.42)	1.22 (1.05–1.43)	0.88 (0.71–1.10)
Institutional care[e]	1.25 (0.95–1.64)	1.23 (0.94–1.62)	0.70 (0.50–0.98)
Household amenities[d]	1.02 (0.999–1.04)	1.02 (0.9998–1.04)	0.99 (0.97–1.02)
	Behavioral domain		
16 yr activity (most–low)[d]	1.22 (1.15–1.30)	1.06 (1.01–1.12)	0.92 (0.85–1.004)
16 yr sports aptitude (less than or equal to average)[e]	1.45 (1.21–1.74)	1.06 (0.90–1.25)	0.97 (0.80–1.18)
16 yr internalizing behavior[c]	1.03 (0.97–1.10)	1.03 (0.97–1.09)	1.02 (0.94–1.10)
16 yr externalizing behavior[c]	1.02 (0.96–1.09)	1.03 (0.97–1.10)	0.95 (0.87–1.03)
16 yr smoking[e]	1.23 (1.02–1.47)	1.01 (0.86–1.18)	0.93 (0.76–1.14)
16 yr alcohol consumption in last week (7+ units–none)[d]	1.04 (0.96–1.14)	0.98 (0.91–1.06)	1.01 (0.92–1.10)

[a]Comparisons are 1) persistently inactive relative to the never inactive (i.e., the most vs the least adverse behavior 33–50 yr), 2) those with deteriorating status relative to the never inactive, and 3) those with improving status relative to the persistently inactive (i.e., those changing inactivity status vs those remaining the same over the age range).
[b]All models have been adjusted for gender and all factors in the table and assessed at 33 yr: qualification level, BMI, number of children in household, mental health, physical limiting illness, and social class.
[c]Per SD increase.
[d]Per increase in scale.
[e]Attribute vs nonattribute.

nonsignificant associations of social factors and cognition with inactivity persistence.

DISCUSSION

In a nationwide general population sample followed from birth to 50 yr, we identified two important findings. First, we found that approximately 31% were inactive at 33 yr, with a similar proportion inactive at 50 yr. Yet, inactivity was only moderately stable within individuals, with 14% persistently inactive and 17% becoming so over the age range. Second, early life physical, social, and behavioral factors were associated with persistent inactivity and deterioration, with RRR ranging from 0.84 (95% CI, 0.78–0.91) per SD increase in 16 yr cognition to 1.47 (95% CI, 1.24–1.75) for low sports aptitude for the persistently inactive. Among the many early life factors examined, only poor hand control/coordination was associated with a lower RRR of improving inactivity status in midadulthood, although the lower RRR of improving inactivity was borderline for institutional care in childhood.

Methodological considerations. Our population sample followed from birth enabled examination of a wide range of prospectively measured early life factors, and we were able to assess adult inactivity stability and change because of the repeated identical measures at 33 and 50 yr. To our knowledge, no other study has investigated such an extensive array of early life factors simultaneously with adult inactivity patterns. We were also able to examine whether associations were independent of several adult factors. However, study limitations are acknowledged. Our (in)activity measure relies on simple questionnaire data and is limited to leisure time, rather than total activity that would include other domains; for example, occupation. As argued previously (27), there is no consistent definition of inactivity, with some studies using failure to meet recommended activity levels (20,26) and others identifying the least active in a population (15,18,37). Our measure, based on self-reported infrequent activity participation (<1 per week), has been used previously (3,12,27,39) and was found to be associated with psychological distress (12) and mortality (3,39). However, misclassification of individuals at either age 33 yr or 50 yr could affect our estimates of stability and change whereas investigation of inactivity over a 17-yr period may not capture the full extent of inactivity stability and change during the intervening period. Nonetheless, our study of inactivity stability and change based on two adult ages extends previous studies of early life factors and (in)activity on the basis of a single age in adulthood (18,37). As acknowledged previously (27), organization of early life factors into three domains is subjective, but such organization afforded a structured and pragmatic approach. Moreover, the domains examined are related to theoretical constructs of health and social capital (29). Some of our early life measures have weaknesses, for example, 16-yr health-related behaviors including activity were self-reported and thus prone to bias. The study is observational; therefore, uncontrolled covariates could account for some of the observed associations. Finally, as with any long-term study, sample attrition occurred over follow-up, although respondents in midadulthood were broadly representative of the surviving cohort (1). Maximizing available data, our models included participants with a measure of inactivity at 33 yr or 50 yr, who, at 50 yr were still living in Britain and we avoided sample reductions due to missing information using multiple imputation.

Interpretation and comparison with other studies. Varying definitions of inactivity hamper comparisons with other studies, but some consistent themes can be identified. Tracking of (in)activity with age has been shown in several studies (24,26,38), including this cohort (25), and here, we extend previous work by showing that tracking continues at a moderate level to age 50 yr. Approximately 14% of the cohort were inactive at both 33 and 50 yr, whereas in a Dutch cohort, 24% never met recommended activity levels over a 10-yr period, from a mean baseline age of 45 yr (26). Over decades of adult life, we found substantial within-individual change in (in)activity status (35% of the population). Thus, our observations are consistent with those of others (2,24,26,41) in suggesting low-to-moderate tracking in adulthood. In addition, although findings for (in)activity tracking from adolescence to adulthood have been reported previously (22,27), the current study is novel in showing that the link between adolescent and adult (in) activity relates not only to inactivity persistence in adulthood but also to inactivity deterioration.

Previous studies identify associations of early life factors with (in)activity at a single age in adulthood (18,37), ignoring stabilities and change or focus on adult factors (e.g., baseline health status in adulthood (26,41)) of (in)activity stability and changes (2,26,34,41). Thus, our findings are important because we show that early life factors are associated with inactivity patterns over decades in adulthood. An important finding of our study is that several factors from different early life domains were associated with inactivity persistence and deteriorating status whereas only poor hand control/coordination was associated with improvement. Given the range of factors considered, our findings imply that early life factors are less relevant to improvement in (in)activity in adulthood and more relevant to persistence and deterioration. The current study suggests that many factors identified in our previous study of early life and adult inactivity (27) are particularly relevant to inactivity persistence in midadulthood. Notably, those with hand control/coordination problems in childhood were more likely to be persistently inactive compared with the never inactive, an association which, to our knowledge, has not previously been investigated. Hand control/coordination problems at one childhood age was associated with a 17% higher risk of persistent adult inactivity; for 12% of the population with problems at two childhood ages, the risk was 37% higher, and for the 4% with problems at three ages, it was 60% higher. We also showed that shorter prepubertal stature was associated with persistent inactivity. Shorter stature in childhood and adulthood are associated with adult morbidity and mortality (8), but to our knowledge, few studies have examined height and subsequent (in)activity (10,27). Our study highlights the

EPIDEMIOLOGY

importance of low cognitive ability in childhood as associated with inactivity persistence. This agrees with previous work showing associations of educational attainment with adult activity (2,15,18,26,37), for example, with the highly educated more likely to be "consistently active" compared with the "consistently inactive" (2). Educational attainment is largely an outcome of abilities and development during early life and throughout childhood; thus, our results emphasize the early origin of the educational attainment–adult activity relation. Not surprisingly, the long-term cognition–inactivity pattern association was no longer evident after allowing for educational attainment, adult social class, and so forth. Several social factors were related to inactivity persistence, including lower class at birth, poor household amenities, parental divorce, and minimal education, with a greater risk for those with the most adverse circumstances. There is limited evidence on associations between early life social factors and subsequent adult inactivity patterns, but parallels can be drawn from associations with other health behaviors. For example, we found an elevated risk of persistent inactivity associated with minimal parental education, which was no longer evident after accounting for adult factors whereas others report that parental education had a strong gradient in daily adult smoking and the effect seemed to be via the respondent's own educational level (16). Associations between institutional care and inactivity persistence were nonsignificant; however, point estimates indicated a higher RRR compared with the never inactive and the nonsignificant association may be due to low prevalence of institutional care (6.3%). Unsurprisingly, all observed associations of social factors with inactivity persistence were no longer apparent after allowing for adult covariates such as social class and educational attainment. Those who smoked in adolescence were more likely to be persistently inactive in adulthood, extending previous findings in adolescence showing that smokers had higher odds of remaining inactive compared with those maintaining activity (31). Because risk behaviors such as inactivity and smoking tend to co-occur (35), the association for adolescent smoking may reflect or anticipate future co-occurring behaviors. Our null findings, with respect to inactivity persistence are also of importance: we found no association with maternal BMI, childhood neglect, 16-yr drinking, internalizing, and externalizing behaviors. These findings suggest that the pathways through which such factors may influence subsequent health are independent of inactivity.

Several of the early life factors associated with inactivity persistence were also associated with a deteriorating inactivity pattern. Notably, those with hand control/coordination problems at one age in childhood had a 12% higher risk of deteriorating inactivity; those with problems at all three ages (i.e., 7, 11, and 16 yr) had a 40% higher risk. Although findings for a deteriorating inactivity pattern were broadly similar to those for inactivity persistence, it is interesting that associations for some social factors (i.e., class at birth and parental divorce) were robust to adjustment for adult covariates, suggesting that there is a long-term association. Such associations over the long term can be viewed in the context of previous work showing these factors to be related to inactivity at 50 yr but not at 33 yr (27). Our current findings, taken together with our previous report, imply that early life social disadvantage is associated with later-life (50 yr) inactivity primarily because of deteriorating status and that the association is unlikely to be due to concurrent adult health (27).

No social or behavioral factor was associated with improving inactivity status in adulthood, and the only physical factor was hand control/coordination problems. Such problems at one age in childhood were associated with a 13% lower risk of improved inactivity status and problems at all three ages (i.e., 7, 11, 16 yr) with a 34% lower risk. It is interesting to note that hand control/coordination was the only factor that was associated with all three adult inactivity patterns, although borderline associations were seen for institutional care. Early life cognitive abilities as well as internalizing and externalizing behaviors were not associated with improved inactivity status, which is surprising given their strong long-term associations with life chances and risk behaviors (29) and our previous demonstration of externalizing behavior associations with inactivity at specific ages in adulthood (27). The lack of early life factor associations with improving inactivity status could imply that more contemporary adult factors influence this activity pattern.

Implications. Inactivity in adulthood is common but varies within individuals as they age. The low-to-moderate tracking seen in our population and elsewhere (24,26,38) highlights the fact that at the population level there may be opportunities for behavior change and for maintaining improvements over the life course. Much of the current literature on benefits of physical activity tends to examine (in) activity at one time point in association with subsequent physical (33) and mental (4) health outcomes. Our findings therefore emphasize the importance of considering longitudinal patterns of (in)activity; and, although some evidence suggests that activity level changes can affect subsequent mortality (5,36), research examining changing (in)activity patterns with future health outcomes is scarce. In conclusion, we found that early life factors are associated with inactivity persistence and deterioration but less so improvement in inactivity. The latter may be related to more contemporary adult factors, which warrant investigation in future work.

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