RESEARCH ARTICLE

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Baseline leisure time activity and cognition more than two decades later

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Objective: Many studies of the relation between factors earlier in life and late-life cognition have a short follow-up time, often less than 10 years. Since cognitive decline can be present up to 20 years prior to dementia it is difficult to distinguish the direction of the relationships without a long follow-up. We analyzed the association between different types of leisure time activity at baseline and cognition more than 20 years later. A wide range of activities was included—political, mental, socio-cultural, social, physical, and organizational activities.

Methods: Baseline studies were random Swedish samples aged 46–75 years (mean 57.4) ($n = 1643$) interviewed in 1968 or 1981. Activities were measured at baseline. Cognition was measured with items from the Mini-Mental State Examination in 1992, 2002, or 2004.

Results: There was a significant association between later cognition and earlier political, mental, and socio-cultural activities controlling for age, age-square, sex, follow-up-time, mobility problems, symptoms of mental distress, employment status, education, adult and childhood socioeconomic status, income, smoking, and drinking. Physical activities had a significant association with cognition only among women. Organizational activities were not significant when controlling for all covariates. Social activities had no significant association. Including all covariates and all leisure activities simultaneously, only mid-life political and mental activities remained significantly related to later life cognition.

Conclusions: These findings add support to the theory that various forms of engagement in mid-life can have a protective effect with respect to cognition in later life. Copyright © 2010 John Wiley & Sons, Ltd.

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Introduction

Age and genetic susceptibility are the most important factors for variation in cognition and cognitive impairment in older adults. It has been suggested that genetic factors explain a third of the variation in late life cognitive impairment (Brandt *et al*., 1993; Reynolds *et al*., 2006). This could lead to a fatalistic view of the possibilities to enjoy good cognitive health in old age. However, research during the past 20 years has revealed several modifiable factors that seem to influence late life cognition. This research was summarized by the NIH Cognitive and Emotional Health Project (Hendrie *et al*., 2006). Protective factors identified by this review include high level of education, high socioeconomic status (SES), good health behaviors, and physical exercise. Another review focused on the hypothesis that an intellectually and socially engaged lifestyle might protect against cognitive impairment in old age (Scarmeas and Stern, 2003). Some studies have looked at activities in general and found them to be protective (e.g., Scarmeas *et al*., 2001; Fritsch *et al*., 2005b). Other studies have focused on specific types of activities. For example, Wilson *et al*. (2002) found cognitively stimulating activities to be protective and Fritsch *et al*. (2005a) found positive effects of participation in novelty-seeking activities. Fratiglioni *et al*. (2004) have reviewed the protective effects of an active social lifestyle, and several studies have

found that leisure-time physical activities were associated with lower risk for dementia in late life (Rovio *et al*., 2005; Andel *et al*., 2008). Researchers have used various classifications of activities. For example, Scarmeas *et al.* (2001) found lower dementia risks among people scoring high in intellectual, physical and social activities. Friedland *et al*. (2001) looked at diversity and intensity of activities and found that persons who later developed Alzheimer's disease had less diversity of activities and less intensity of intellectual activities compared to controls.

Many studies of the relation between leisure time activities and cognition have a short follow-up time, often less than 10 years. Since cognitive decline can be present up to 20 years prior to a dementia diagnosis (Braak *et al*., 1999), and cognitive decline may lead to changes in activity, it is difficult to distinguish the direction of the relationships. For instance, a study with a 6-year follow-up showed that baselines activities did not influence later cognition, but that baseline cognition influenced later activities (Aartsen *et al*., 2002). This finding emphasizes the importance of having a long follow-up.

In this study we analyze the correlation between different leisure time activities at baseline and cognition more than 20 years later. Persons in midlife are often involved in several types of leisure time activities and are engaged in society in different ways. Different activities may be differently related to health. The baseline questions available to us included a wider range of leisure time activities than normally used in similar studies. Activities are grouped into political, mental, socio-cultural, social, physical, and organizational activities. Political and organizational activities reflect high levels of social engagement and have seldom been studied.

The correlation between different leisure time activities and cognition is studied controlling for a number of the well-known protective factors mentioned above—education, occupation and SES in adulthood and childhood. We also control for sex, since earlier studies have found sex differences in cognition (Fratiglioni *et al*., 1997), age and age-squared that reflects the acceleration of cognitive impairment in advanced ages. Controls are included for mobility problems, emotional distress, and employment that may have affected engagement in leisure time activities at baseline and the life style factors smoking and alcohol drinking.

Methods

Study population

The study population was comprised of participants in two baseline surveys from 1968 and 1981. Both surveys were random samples of the Swedish population. As seen in Figure 1, 1871 persons aged 56–75 were interviewed in 1968. Of these, 534 were still alive in 1992 and cognitive data could be collected for 430 individuals. From the 1981 baseline survey, cognitive data could be collected for 416 individuals in 2002 and for 797 individuals in 2004. The 2004 survey included 297 individuals who also responded in 2002. A total of 1643 follow-up observations were made (Lundberg and Thorslund, 1996; Jonsson and Mills, 2001).

All surveys except 2004 were based primarily on face-to-face interviews in homes or institutions. The 2004 survey was based on telephone interviews. Proxy (informant) interviews were conducted when the respondent could not participate directly; these interviews did not include the test of cognition.

Measures

The outcome measure cognition was based on items from the Mini-Mental State Examination (MMSE) (Folstein *et al*., 1975) available in all three follow-ups:

(1) Registration and repeating three objects (1 point if all three registered after one trial).
(2) Orientation: (year/month/date/country) (0–4 points).
(3) Delayed recall of three objects (0–3 points).
(4) Attention/concentration: Subtracting 7 from 100 five times (0.4 points for each correct answer, to adjust the importance of this item in the total score (0–2 points).

The range of the total score was 0–10, with values rounded to the nearest integer (see Table 2). For a description of this measure and comparisons with larger Swedish studies (Gatz *et al*., 2005) with the complete MMSE as well as clinical diagnoses for dementia, see (Parker *et al*., 1996, 2005).

Leisure activities and all control variables except age and follow-up time were from baseline surveys.

Political activities: ever having appealed a decision made by a public authority, delivered a speech at a meeting, written an article or a letter to the editor, or participated in a demonstration during the past year. *Organizational activities:* being an active trade union member (at least attending meetings), member of a political party, sports, temperance, religious, or other organization. Each of these items had two response categories that were scored ''no'' (0) or ''yes'' (1) and summed to form scales.

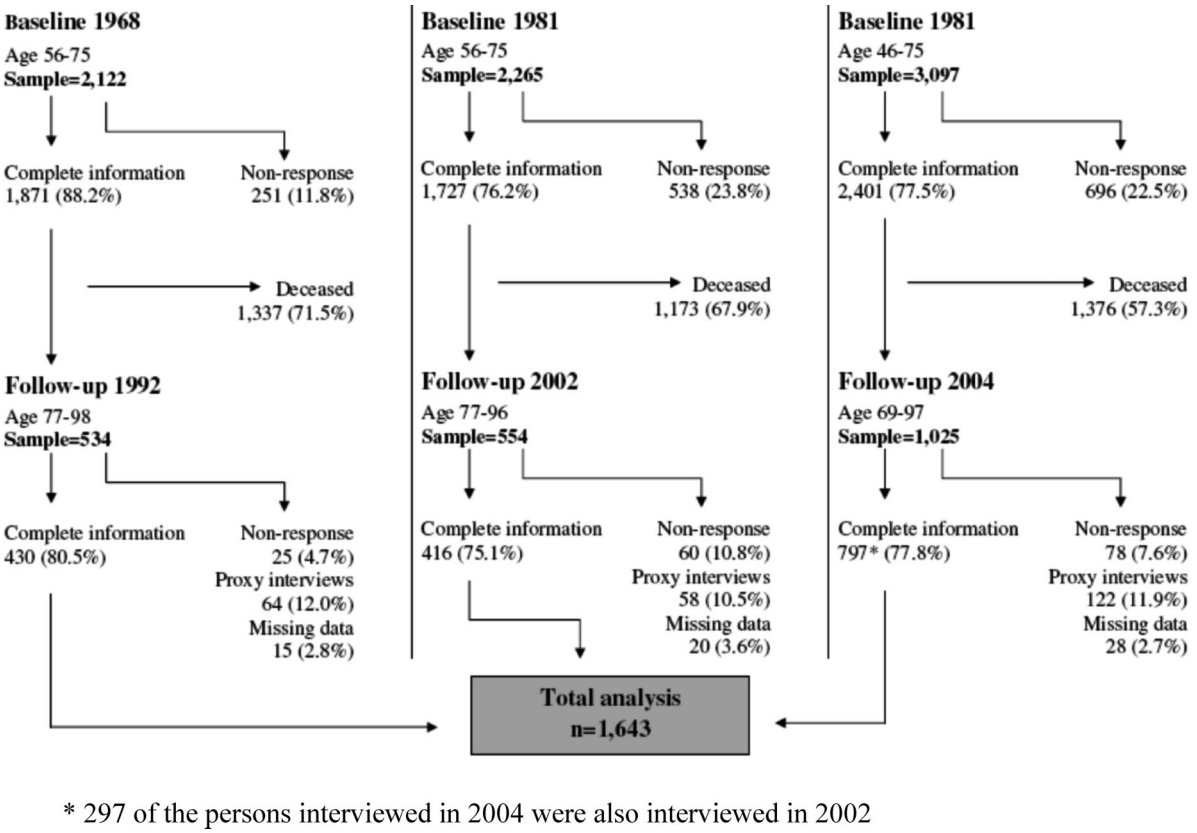

Figure 1 Description of the study population.

Mental activities: reading books, playing an instrument/singing, and doing hobby activities. *Socio-cultural activities:* going to the movies, the theatre, and attending study circles. *Social activities:* four questions concerning visiting and/or being visited by friends and/or relatives. *Physical activities:* doing sports, gardening, and dancing. These questions had three response categories that were scored "no" (0), "yes sometimes" (1), and "yes often" (2), and summed to form scales.

Since scales had different numbers of items and scoring schemes, each scale was transformed into a standardized score (mean = 0, standard deviation = 1) in order to retain comparability.

We tested whether the association between each index of leisure time activity and cognition was straight or curvilinear, by giving activities both linear and quadratic representation. Results revealed strong curvilinearity for socio-cultural activities; therefore we have given this activity curvilinear representation. The representation having the best fit was: new curvilinear variable = ori-original index − (original index^2/9). With this transformation the original value 1 corresponded to 0.89, 2–1.56, 3–2, and both original values 4 and 5–2.22. The curvilinear specification of socio-cultural activities implies that the effect of each step of the activity score is assumed to decrease as the activity level increases. For example, the difference between a score of 0 and 1 is assumed to be greater than between 2 and 3.

There were significant correlations (Spearman's ρ) between all leisure time activities ($p < 0.05$), except between mental and organizational activities, and between political and social activities. These correlations imply that active persons are often active in more than one activity. The strongest correlations were between organizational and political activities ($\rho = 0.38$), between mental and socio-cultural ($\rho = 0.27$) and between political and socio-cultural ($\rho = 0.26$) (see Table 1).

Age at follow-up (69–98 years) was given linear and quadratic representation to capture both linear decline and acceleration of decline with increasing age.

Follow-up time from 1968 to 1992 was 24 years, from 1981 to 2002 was 21 years, and from 1981 to 2004 was 23 years (average 22.8 years).

Mobility problems: an index of self-reported ability to walk up and down stairs, walk 100 m briskly, and run 100 m without problems (not able = 1, range 0–3).

Symptoms of mental distress: an index of self-reported depression, psychological problems, sleeping

Table 1 Correlations (Spearman's ρ) between leisure time activities

Leisure time activities	Political	Mental	Socio-cultural	Social	Organizational
Mental	0.14 (<0.001)				
Socio-cultural	0.26 (<0.001)	0.27 (<0.001)			
Social	0.03 (0.164)	0.16 (<0.001)	0.18 (<0.001)		
Organizational	0.38 (<0.001)	0.02 (0.334)	0.16 (<0.001)	0.06 (0.020)	
Physical	0.19 (<0.001)	0.09 (<0.001)	0.24 (<0.001)	0.15 (<0.001)	0.16 (<0.001)

p-Values are shown in parenthesis.

problems, and nervous problems. These questions were coded 0 for ''no,'' ''yes, moderate'' (1), and ''yes, severe'' (2) (range 0–8).

Employment status: a dichotomous variable where employed are coded as active in the labor market.

Number of years of *education* was based on a single item question.

Adult SES was based on occupation at time of baseline interview; unemployed persons were asked about last occupation, and pensioners about main lifetime occupation. Housewives (26.9%) were coded according to their husbands' social class. Occupations are coded into four groups: (1) unskilled blue-collar workers, (2) skilled blue-collar workers (needing normally two years of formal training), small farmers, and entrepreneurs without employees, (3) lower white-collar workers, large farmers, and entrepreneurs with 1–19 employees, and (4) intermediate and upper white-collar workers, entrepreneurs with at least 20 employees, and academic professionals.

Childhood SES was based on fathers' occupation. The coding of childhood SES was the same as the coding of adult SES.

Income is from the national tax registry. Income from 1981 was converted to 1968 values. Income has been log-transformed and a dummy variable was created for those with zero income. Most persons with zero income were housewives.

Smoking: Non-smoker; smoking $\leq$10 cigarettes (corresponding to 20 pipes or 5 cigars); >10 cigarettes.

Alcohol drinking: Non-drinker; moderate drinker; drinking more than moderately. Moderate drinking is less than two times per month and normally not more than 1–2 glasses. This low level for moderate drinking was necessary due to different wordings of the questions in the 1968 and 1981 surveys.

Follow-up time, mobility problems, symptoms of mental distress, education, and log-transformed income were given linear representation. Social class, smoking and alcohol drinking was given dummy representation.

Table 2 Univariate descriptive statistics of cognition and leisure time activity indexes

	Cognition[a]	Leisure time activities					
		Political	Mental	Social	Organizational	Physical	Socio-cultural
Mean	8.2	0.8	2.5	5.0	1.3	1.8	1.3
SD	1.9	1.1	1.3	1.7	1.0	1.3	1.2
Median	8.6	0	3	4	1	2	1
IQR[b]	7.4–9.6	0–1	2–4	4–6	1–2	1–2	0–2
Skewness	−1.7	1.2	−0.1	0.3	0.5	0.5	0.7
Value		Proportion (%)					
0	1.0	52.4	8.0	0.7	23.5	18.4	35.1
1	0.7	23.8	14.9	0.7	38.1	19.8	25.7
2	1.0	13.4	26.9	3.6	25.4	37.7	21.4
3	1.2	7.6	24.6	3.8	10.8	15.3	13.3
4	1.8	2.8	22.8	43.9	1.0	6.3	3.5
5	3.5		2.2	11.8	0.2	1.9	1.0
6	4.9		0.6	17.5		0.7	0
7	12.7			4.4			
8	17.7			13.5			
9	25.9						
10	29.6						

[a]Presented values are rounded to closest integer.
[b]Inter-quartile range.

Statistical analyses

Ordered logistic regressions were chosen to analyze the correlation between independent factors and cognition because, unlike linear regression, they do not imply equal step sizes nor do they require normally distributed variables.

The results are from bivariate regressions and three sequential multiple models. Model 1 was controlled for age, age-square, sex, and follow-up-time, model 2 for the same variables as model 1 and mobility problems, symptoms of mental distress, employment status, education, and adult and childhood SES. Because there were correlations between activities, in Model 3 we entered all leisure time activities simultaneously, with the same control variables as model 2.

Due to the sampling procedure, 297 persons had been interviewed both in 2002 and 2004. Both scores were included as outcomes in the analyses. If repeated measures from the same person are treated as independent, this could lead to erroneous low standard errors. To control for this possibility, we used the cluster-correlated robust estimate of variance (Huber, 1967; White, 1980; Williams, 2000).

Results

Table 2 presents univariate descriptions of cognition and leisure time activities. *Cognition* was not normally distributed, for example, 29.6% had the maximum value of 10. Therefore our outcome measure does not discriminate well among persons with good cognition. The cognitive test, however, is a screening instrument and its greatest strength therefore lies in distinguishing those with cognitive dysfunction rather than in quantifying performance differences among those with good cognition.

As can be seen from Table 2, none of the *leisure time activities* were normally distributed. Social activities were skewed to the left with 13.5% having the maximum value. Political, organizational, and physical activities were skewed to the right with large proportions having no participation (a score of zero).

Age at follow-up ranged from 69 to 98 years (mean 80.2) (Table 3.).

About the same number of persons were interviewed in 1992 ($n = 430$) and 2002 ($n = 416$). Since the 2004 follow-up survey covered a wider age span (69+), more persons ($n = 797$) were interviewed that year.

Few people had less than 6 years or more than 10 years of education (IQR 6–10), which is typical for this age cohort in Sweden.

The most common adult SES (own social class) for the studied persons was unqualified blue-collar workers (33.4%). The most common social class for their fathers (childhood SES) was qualified blue-collar worker. While this appears to imply downward mobility between generations, note that adult SES includes a majority of women, who have in general lower social class then men. When we compare only men with their fathers (not shown), we see that there has been substantial upward mobility between generations.

Bivariate analyses of the association between control variables and cognition show significant associations between low cognition and higher age, being female, having mobility problems, symptoms of mental distress, less education, not being employed, having lower adult and childhood SES, low income, and drinking more than moderately (Table 3).

When all control variables were entered simultaneously, mobility problems, education, and adult SES continued to have significant associations with cognition, income with $p < 0.10$. The combined effect of age and age-square was significant ($p < 0.001$) revealing a clear age gradient (Table 3).

The relation between leisure time activity and cognition

Table 4 presents the relation between baseline leisure time activity and later cognition. Political, mental, socio-cultural, and organizational activities were significantly related to cognition, both in bivariate analyses as well as when controlling for age, sex, and follow-up time for both men and women, whereas physical activities were only correlated with cognition among women. Social activities were not correlated with cognition.

In the fully adjusted model (model 2), additionally controlling for mobility problems, symptoms of mental distress, employment status, education, adult and childhood SES, income, smoking, and alcohol drinking the relations were strongest for political, followed by mental and socio-cultural activities. Physical activities were correlated to better cognition for women only.

Organizational activities were significantly related to cognition in model 1, but not in the fully adjusted model (model 2). If any of the additional variables in model 2 except drinking and income were added to model 1, organizational activities stopped being significant.

In model 3 the same controls were used as model 2, and all leisure time activities were entered simultaneously. Model 3 was included as a complement to model 2 since it shows the effect of the different leisure time activities controlling for the fact that active

Table 3 Descriptive statistics for independent variables and the association between late life cognition and control variables (results from ordered logistic regressions). All independent variables except age and follow-up time are from baseline

Control variable	Descriptive statistics	Association to cognition[a]			
		Bivariate analyses		Adjusted for other control variables	
		β	*p*-Value	β	*p*-Value
Age at follow up (linear + quadratic representation)			**<0.001**[b]		**<0.001**
Age (linear)					
Range	69–98				
Mean	80.2	**−0.08**[b]	<0.001	−0.03	0.307
IQR[c]	77–84				
$Age^2/100$		−0.13[d]	0.222	−0.14	0.188
Sex	%				
Women	58.7	**−0.21**	0.027	0.17	0.149
Men	41.3	0 (ref)		0 (ref)	
Follow-up time (years)	%				
21 (1981–2002)	25.3				
23 (1981–2004)	48.5	0.80	0.353	0.13	0.896
24 (1968–1992)	26.2				
Mean	22.8				
Mobility problems	%				
0	70.8				
1	13.8	**−0.37**	<0.001	**−0.19**	0.001
2	8.8				
3	6.6				
Symptoms of mental distress					
Range	0–8				
Mean	0.5	**−0.13**	0.006	−0.06	0.236
IQR[c]	0–1				
Employment status	%				
Employed	70.1	**0.79**	<0.001	0.11	0.453
Unemployed	29.9	0 (ref)		0 (ref)	
Years of education					
Range	0–29				
Mean	8.4	**0.12**	<0.001	**0.06**	0.004
Median	7				
IQR[c]	6–10				
Adult socioeconomic status	%		**<0.001**[f]		**0.001**[e]
Blue-collar (unskilled)	33.4	0 (ref)		0 (ref)	
Blue-collar (skilled)	21.1	**0.27**	0.040	**0.35**	0.015
Lower white-collar	19.5	**0.67**	<0.001	**0.48**	<0.001
Intermediate and upper white-collar	26.0	**0.83**	<0.001	**0.40**	0.004
Childhood socioeconomic status	%		**0.038**[f]		0.268[f]
Blue-collar (unskilled)	24.7	0 (ref)		0 (ref)	
Blue-collar (skilled)	35.1	0.13	0.300	0.14	0.281
Lower white-collar	28.4	0.07	0.589	−0.04	0.791
Intermediate and upper white-collar	11.0	**0.47**	0.003	0.14	0.473
Missing and unclassifiable	0.9	0.67	0.229	**0.71**	0.086
Yearly income in 1000 SEK, 1968 value					
% with 0 income	12.3	**−0.47**	<0.001	0.16	0.494
Range	0–844				
Mean	Among persons with income >0	81			
Median	63	**0.31**	<0.001	**0.19**	0.053
IQR[c]	37–90				
Smoking	%		0.510[e]		0.756[e]
No	74.6	0 (ref)		0 (ref)	
Yes, 1–10 cigarettes	12.8	−0.04	0.741	−0.10	0.460
Yes >10 cigarettes	12.5	0.15	0.298	−0.04	0.806
Alcohol drinking	%		**0.097**[e]		0.493[e]
No	24.4	0 (ref)		0 (ref)	
Moderate	44.9	0.18	0.147	−0.06	0.631
>Moderate	30.7	**0.29**	0.031	−0.17	0.253
Total	1643				

[a]Follow-up time, mobility problems, symptoms of mental distress, years of education, and log income (for income > 0) are given linear representation. Age is given linear and quadratic representation.
[b]Results with $p < 0.100$ in **bold**.
[c]Inter-quartile range.
[2]Square.
[d]Controlled for age given linear representation.
[e]*p*-Value for whole variable.

Table 4 The association between leisure time activity at baseline and late life cognition (results from ordered logistic regressions)

Leisure time activities	Bivariate		Model 1		Model 2		Model 3	
	β	p-Value	β	p-Value	β	p-Value	β	p-Value
Political	**0.30**[a]	<0.001	**0.30**	<0.001	**0.19**	<0.001	**0.17**	0.004
Mental	**0.19**	<0.001	**0.26**	<0.001	**0.15**	0.005	**0.11**	0.047
Socio-cultural[b]	**0.29**	<0.001	**0.25**	<0.001	**0.10**	0.050	0.04	0.415
Social	0.08	0.113	0.08	0.111	0.04	0.423	0.01	0.904
Organizational	**0.14**	0.005	**0.11**	0.050	0.04	0.448	−0.03	0.628
Physical, all	**0.21**	<0.001	**0.14**	0.006	0.07	0.173	0.05	0.375
Men	0.07	0.336	0.01	0.886	−0.04	0.607	−0.06	0.477
Women	**0.31**	<0.001	**0.25**	<0.001	**0.17**	0.017	**0.14**	0.055

Model 1: Controlled for age, age-square, sex, and follow-up-time.
Model 2: Controls as model 1 + mobility problems, symptoms of mental distress, employment status, years of education, adult and childhood socioeconomic status, income, smoking, and alcohol drinking.
Model 3: Controls as model 2, all leisure time activities entered simultaneously.
[a]Results with $p < 0.100$ in bold.
[b]Given curve-linear representation. When the original index is used in the analyses it is significant in the bivariate analyses and model 1 and significant on the 10% level in model 2.

persons often were active in more than one activity, as shown by the correlations between several of the activities. Including all leisure time activities, only political and mental activities were associated with late life cognition. The association between physical activities and cognition was significant at the 10% level among women.

For all models we tested if the correlations were different for men than for women, and for the different follow-up years. There are no differences between the follow-up years, and sex differences were found only for physical activities.

Discussion

There was a significant association between different leisure time activities at base-line and cognition on average 23 years later. Associations were found for political, mental, and socio-cultural activities for men and women, and between cognition and physical activities among women, controlling for age and a number of indicators for health and SES.

Social activities had no significant association. Organizational activities were significant when only controlling for age, sex, and follow-up-time but not for other covariates. When all controls and all leisure activities were included simultaneously, only political and mental activities were significantly related to cognition. Physical activities were significant on the 10% level among women.

These findings add support to the hypothesis that various forms of engagement in mid-life are correlated to better late life cognition. Previous summaries of the literature have suggested that the strong protective factors include education (spanning childhood and early adulthood), social engagement, physical activity, mental activities, and emotional health (Rovio *et al*., 2005; Hendrie *et al*., 2006; Fratiglioni *et al*., 2007). Notably, these factors are malleable to the extent which engagement in adult life can be promoted through interventions and policy.

Education and other forms of intellectual stimulation have been hypothesized to increase cognitive reserve through either increasing synaptic density (Katzman, 1993) or increasing the ability to compensate for loss (Stern *et al*., 1999). The two strongest associations in our results are between cognition and political or mental activities. Both these groups of activities have a strong intellectual component and are significant even controlling education and socioeconomic conditions.

Another possible mechanism is self-efficacy. Political activities (having spoken at a meeting, written a letter to the editor, appealed a decision, or participated in a demonstration) reflect both mental activity as well as self-efficacy. These are people who felt that their actions were worthwhile that they could have an effect on political outcomes. A correlation has been found between self-efficacy and cognition (Seeman *et al*., 1996). The combination of intellectual content and self-efficacy may explain the strong correlation of political activity to cognition.

Physical activity has been shown to be correlated with better cognition in late life (Rovio *et al*., 2005; Dishman *et al*., 2006; Hendrie *et al*., 2006). There are several possible mechanisms at work here. Physical activity has been shown to influence brain plasticity by facilitating neuroprotective, and neurogenerative, processes (Dishman *et al*., 2006). Inactivity has been shown

to be associated with cardiovascular problems, which in turn can lead to cognitive decline (Kivipelto *et al*., 2001). We found a significant relation between physical activity and cognition for women only, but no relation for men. There is no consensus regarding sex differences in the effect of physical activity (Colcombe and Kramer, 2003; Dik *et al*., 2003; Kramer *et al*., 2006). Variations could be due to sex differences in how the physical activity is performed and what kind of activity has been studied (Fratiglioni *et al*., 1997). There was a somewhat larger proportion of women (21.2%) than men (14.3%) *not* performing physical activities. It is unlikely that this difference alone explains the sex difference in the correlation between physical activity and cognition.

Some studies, but not all, show a protective effect of social activity on age-related cognitive decline (Bassuk *et al*., 1999; Seeman *et al*., 2001; Aartsen *et al*., 2002; Hendrie *et al*., 2006). For example, Holtzman *et al*. (2004) found that both greater size of social network and more frequent contacts were associated positively with MMSE measured 12 years later, while Saczynski *et al*. (2006) found no association between midlife social engagement and late life risk of dementia. Differences between studies could arise from different ways to measure social activities. The effect on cognition may depend more on quality than quantity of social contacts. In this study there was no significant association between social activities and late-life cognition. Our index of social activities is based on four questions on visiting/being visited by friends and/or relatives and does not reflect quality of contact or whether the individual voluntarily chose the contacts.

Strengths and limitations of the study

The sample used in this study is representative of the elderly population of Sweden and has a low non-response rate. The long follow-up (average of 23 years) between the cognitive outcome and measurement of activities and controls minimizes the risk of undetected impairments in cognition influencing activity participation. The longer the interval between measurement of activities and cognitive assessment, the more confident we can be in implying a temporal and causal relationship (Scarmeas and Stern, 2003).

Another strength of this study is that a wide range of activities were included—political, mental, socio-cultural, social, physical, and organizational activities—and that information about participation in leisure time activities was gathered directly from the respondents at the time they were participating in the activities. Many studies that cover such long periods of time must rely on retrospective data or information from proxies or other sources (Friedland *et al*., 2001; Fritsch *et al*., 2007). A drawback is that frequency of participation was the respondents' own judgments.

The outcome measure for cognition is based on items from the MMSE. Such a brief cognitive measure may not be sensitive to moderate levels of cognitive impairment. Survival bias may have affected results since less active persons have higher mortality risks (Lennartsson and Silverstein, 2001; Konlaan *et al*., 2002; Agahi and Parker, 2008). Both of these limitations would lead to an underestimation of the effects, thus our results would represent an underestimation of the association between leisure time activity and cognition.

One limitation of this study is the absence of a baseline measure of cognition. Even with this long follow-up we cannot rule out that some people had low cognition their entire life. This is however less likely, since those who score low on our cognitive screening measure are clearly cognitively impaired and it is unlikely that they were this impaired earlier in their lives. There is also a possibility of reverse causality. Baseline participation in activities may have been influenced by cognition or intelligence, which was not available in the baseline studies. Intelligence, however, is strongly correlated with parents' and own SES, and years of education (Neisser *et al*., 1996). These variables partially control for the possible confounding effect of intelligence. Intelligence is also correlated to leisure time activities with a strong mental component (Ghisletta *et al*., 2006), such as political and mental leisure time activities. It could, therefore, be argued that the strong effect of political and mental activities found in this article, even when controlling for each other in the same model, also indicates that there is a strong correlation between cognition and these activities independent of baseline intelligence.

Conclusions

Our results suggest that a range of leisure time activities influence cognition more than 20 years later. We have found significant associations between leisure time activities (political, mental, and socio-cultural among both men and women and physical activities among women) at baseline and cognition 21–24 years later even controlling for a number of possible confounders. These results emphasize the long-term importance of policies to encourage an active life style among middle age adults. With lifestyle interventions in midlife it may be possible to increase the probability for a cognitively vital late life.

Key points

- Cognitive decline can be present many years prior to dementia.
- This study uses longitudinal data spanning 23 years to analyze late life cognition in relation to previous participation in leisure time activities (political, mental, socio-cultural, social, physical, and organizational).
- There was a significant association between cognition and political, mental, and socio-cultural activities controlling for age, sex, physical and mental health, SES, and health behavior.
- Previous physical activities were correlated with later cognition only among women.

Conflict of interest

None known.

Ethics

All studies in the LNU/SWEOLD-panel are approved by ethics committees: LNU 1968 and 1981, the Swedish Data Inspection Board, dnr. 8281-74, and 6920/90; SWEOLD 1992, local ethics committee at Uppsala University Hospital, dnr. 247/91; SWEOLD 2002, the regional research ethics committee at Karolinska Institutet, dnr 03-413; SWEOLD 2004, the regional ethics committee in Stockholm, dnr 387.

Author contributions

I.K. had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: I.K.; acquisition of the data: M.G.P., C.L., and I.K.; drafting of the manuscript: I.K.; critical revision of the manuscript for important intellectual content: I.K., M.G.P., M.G., and C.L.; statistical analysis: I.K.; study supervision: I.K., M.G., M.G.P., and C.L.; obtained funding: M.G.P.

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