Author(s): Poranen-Clark, Taina; von Bonsdorff, Mikaela; Törmäkangas, Timo; Lahti, Jari; Wasenius, Niko; Räikkönen, Katri; Osmond, Clive; Salonen, Minna K.; Rantanen, Taina; Kajantie, Eero; Eriksson, Johan G.

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Intellectual Ability in Young Adulthood as an Antecedent of Physical Functioning in Older Age

Taina Poranen-Clark[1,2], **Mikaela B. von Bonsdorff**[1], **Timo Törmäkangas**[1], **Jari Lahti**[2,3], **Niko Wasenius**[2], **Katri Räikkönen**[3], **Clive Osmond**[4], **Minna K. Salonen**[2,5], **Taina Rantanen**[1], **Eero Kajantie**[5,6,7], and **Johan G. Eriksson**[2,5,8]

[1]Gerontology Research Center and Department of Health Sciences, University of Jyväskylä, Finland [2]Folkhälsan Research Centre, Helsinki, Finland [3]Institute of Behavioural Sciences, University of Helsinki, Helsinki, Finland [4]MRC Lifecourse Epidemiology Unit, University of Southampton, Southampton, United Kingdom [5]Department of Chronic Disease Prevention, National Institute for Health and Welfare, Helsinki, Finland [6]Hospital for Children and Adolescents, Helsinki University Central Hospital and University of Helsinki, Finland [7]Department of Obstetrics and Gynecology, MRC Oulu, Oulu University Central Hospital and University of Oulu, Oulu, Finland [8]Department of General Practice and Primary Health Care, University of Helsinki and Helsinki University Hospital, Helsinki, Finland

Abstract

Objectives—Low cognitive ability is associated with subsequent functional disability. Whether this association extends across adult life has been little studied. The aim of this study was to examine the association between intellectual ability in young adulthood and physical functioning during a 10-year follow-up in older age.

Methods—360 persons of the Helsinki Birth Cohort Study (HBCS) male members, born between 1934- 1944 and residing in Finland in 1971, took part in The Finnish Defence Forces Basic Intellectual Ability Test during the first two weeks of their military service training between 1952-72. Their physical functioning was assessed twice using the Short Form 36 (SF-36) questionnaire at average ages of 61 and 71 years. A longitudinal path model linking Intellectual Ability Test score to the physical functioning assessments was used to explore the effect of intellectual ability in young adulthood on physical functioning in older age.

Results—After adjustments for age at measurement, childhood socioeconomic status and adult BMI (kg/m^2), better intellectual ability total and arithmetic and verbal reasoning subtest scores in young adulthood predicted better physical functioning at age 61 years (P-values < 0.021). Intellectual ability total and arithmetic and verbal reasoning subtest scores in young adulthood had indirect effects on physical functioning at age 71 years (P-values < 0.022) through better physical

Corresponding author and reprint requests: Taina Poranen-Clark, MSc, Gerontology Research Center and Department of Health Sciences, University of Jyväskylä, PO Box 35 (Viveca), FI-40014 University of Jyväskylä, Tel. +358 50 566 3719, taina.poranen-clark@jyu.fi.

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functioning at age 61 years. Adjustment for main chronic diseases did not change the results materially.

Conclusion—Better early life intellectual ability helps in maintaining better physical functioning in older age.

Introduction

People with higher early life intellectual abilities tend to live longer and lead healthier lives[1]. Early adulthood, as a period when brain development peaks, is a critical milestone in the development of intellectual abilities in adulthood[2]. Better early life cognitive ability is a key ingredient of cognitive reserve and can protect against cognitive decline[3]accompanied with declines in functional status in later life[4]. Cognitive ageing has implications for motor performance in older age[5] as cognitive functions play an important role in skilled motor performance[6]. So far, only few studies have investigated the association between early life intellectual ability and physical functioning in later life[7, 8]. To our knowledge this is a first study where this association has been studied during 10-year follow-up in older age.

Methods

Study population

The study population belongs to the Helsinki Birth Cohort Study (HBCS), which includes 8760 participants who were born between 1934-1944 and who had attended child welfare clinics and resided in Finland in 1971[9–12]. Of these, we were able to identify 2786 Finnish male military conscript who took an intellectual ability test during their mandatory military service at a mean age of 20.3 years between 1952-1972. Of them, 640 men participated in the clinical examinations between 2001 and 2004. A total of 1094 participants (478 men and 616 women) attended the follow-up clinical examinations between 2011 and 2013[13]. Complete data, i.e. military intellectual ability test score measured in early adulthood and both physical functioning assessments at age 61 and 71, were available for 360 participants (Supplementary data). The study complies with the guidelines of the Declaration of Helsinki and the Hospital District of Helsinki and Uusimaa approved the study. All participants gave a written informed consent. Intellectual ability data were linked with permission from the Finnish Defence Forces.

Intellectual ability

The Finnish Defence Forces Basic Intellectual Ability Test was developed by the Finnish Defence Forces Educational Development Centre and was compulsory for all new recruits during the two first two weeks of their military service. Administration of the test has been described in detail previously[11, 14, 15]. Briefly, the test battery includes arithmetic, verbal and visuospatial reasoning subtests measuring general cognitive ability and logical thinking. Each subtest includes 40 multiple choice questions ordered by difficulty (range 0-40 points). Correct answers in each subtest were summed and the arithmetic mean was used as an index of intellectual ability (Supplementary data).

Physical functioning

Physical functioning was assessed at the first clinical examination (2001-2004) and again at the 10-year follow-up (2013) using the Finnish validated version of the RAND 36- Item Health Survey 1.0 [Short Form 36 (SF-36)]. The SF-36 has been found to be a reliable and valid measure of physical functioning in the Finnish older population[16, 17]. We used the ten-item subscale on physical functioning. The items were coded into 0= great deal of difficulty or unable to perform, 50= some difficulty, 100= no difficulty, and the summary score was divided by 10. Higher scores imply better physical functioning. The ten-item SF-36 physical functioning score has been described in detail previously[18].

Covariates

We selected age at military service and ages at the clinical examinations, childhood socioeconomic status determined by father's occupational status, adult body mass index (BMI), and main chronic diseases as covariates[8, 19]. Father's occupational status indicated by the highest occupational class was extracted from the birth records, child welfare and school healthcare records and was coded as upper middle class, lower middle class, manual workers or unknown occupation (Central Statistics Office of Finland, 1989). Weight and height were measured at the clinical examination and BMI was calculated (kg/m^2). Main chronic diseases were asked using questionnaires at the clinical examinations.

Statistical analyses

Student's *t*-test was used for comparing means for normally distributed variables and Kruskal-Wallis H test for non-normally distributed continuous variables. Pearson's chi-square test was used for comparing proportions in categorical variables. Due to a noticeable ceiling effect of the physical functioning summary score at both measurements, we treated this variable as censored. A longitudinal path model for these outcomes was used to explore the effect of intellectual ability in young adulthood on physical functioning in older age (Supplementary data). Standardized values of the intellectual ability test scores were used in the path models. Since the age range varied for the three waves of measurement, each measure was adjusted accordingly in the model. We additionally adjusted for childhood socioeconomic status, adult BMI and main chronic diseases. For all tests two-tailed p-values are reported and the level of significance was set at $p<0.05$. The analyses were carried out with SPSS IBM version 22.0 (SPSS, Armonk, NY, IBM Corp) and Mplus (version 7, 2012; Muthén &Muthén, Los Angeles, CA).

Results

Characteristics of the study participants are presented in Table 1.

The longitudinal path model including the censored physical functioning variables revealed a direct positive association between higher total intellectual ability score (P=0.007), arithmetic reasoning (P=0.004) and verbal reasoning (P=0.021) in early adulthood and better physical functioning at the first assessment in 2001-04 (adjusted for age at each measurement). Physical functioning at the first assessment predicted physical functioning at the 10-year follow-up (P<0.001). Intellectual ability total score (P=0.007), arithmetic reasoning (P=0.004) and verbal reasoning (P=0.022) in early adulthood had an indirect effect on physical functioning at follow-up in 2013 through the first assessment physical functioning. Further adjustments for childhood socioeconomic status and adult BMI did not attenuate the results (Table 2). Adjustment for main chronic diseases (heart congestion, myocardial infarction, angina pectoris, hypertension, diabetes) did not change the results materially. All the models fitted well, described in Table 2.

Discussion

Men who had better intellectual ability in early adulthood had better physical functioning in early old age. Better intellectual ability in early adulthood had also an indirect effect on physical functioning after the 10-year follow-up through the first assessment of physical functioning. Our study findings thus suggests that intellectual ability in early adulthood, often considered to be the peak of cognitive development[20], may track over to physical functioning in older age.

Physical and cognitive functioning are important factors for maintaining functional independence and quality of life in older age[21]. Previous studies have confirmed the link between cognitive and physical functioning[22]. Deterioration in the structure or function of the central nervous system has negative effects on the execution of physical tasks in old age[5]. Executive functions are high-level cognitive functions that control and guide goal-directed motor performances[23]. Impairment in executive functioning has been linked with declines of functional status in older age[24]. Findings from the current study might suggest that the association between intellectual ability in young adulthood and physical functioning in older age is mediated by the function of premotor cortex on lateral frontal lobe which supports the executive control of action and attention[6, 25]. Better development of the central nervous system in early life, resulting in higher peak level of intellectual ability in early adulthood, may have far-reaching effects on cognitive reserve capacity and thus also be related to better physical functioning in older age. Persons with higher early life cognitive ability may have lower subsequent risk of cognitive impairment[26] accompanied with decline in physical functioning[4].

The longitudinal study design is one of the strengths of this study. Intellectual ability in this study was measured at the age when it is likely that the brain is fully matured or at least near full maturation[27] and unlikely that cognitive decline would yet be present[28]. In addition, we were able to study physical functioning in older age at two different time points in 10-year follow-up. We were able to use data on socioeconomic status from childhood. There are however some limitations in our study. First, our results might not be generalized to other cohorts nor to women. Further, people who participated in the follow-up examinations in 2013 were younger, had higher childhood socio-economic status, and had better physical functioning scores at the first examination compared to those who did not participate in the follow-up. The fact that the study population was rather homogeneous may result in an underestimation of the associations found between intellectual ability in early adulthood and physical functioning in old age. We used self-reported data on physical functioning, which may cause reporting bias. However, high correlations between self-reported and objectively measured physical performance have been reported[29]. Finally, there may have been other possible factors during the life course that may have affected the association between intellectual ability in early adulthood and physical functioning in old age which we have not been able to control for in this study. The associations could be explained by cumulative effect of intelligent people being more educated, having higher occupational status and leading healthier life-styles[30]. However, adjustment for main chronic diseases or adult BMI did not change the results.

Conclusion

To conclude, we found that persons who had better intellectual ability in early adulthood had better physical functioning in older age. Better early life intellectual ability helps in maintaining better physical functioning in older age.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of the participants (n=360).

Characteristics	Mean (SD)
Age at military service 1952-72 (years)	20.3 (1.6)
Age at clinical testing in 2001-04 (years)	60.9 (2.3)
Age at clinical testing in 2013 (years)	71.4 (2.2)
BMI at clinical testing in 2001-04 (kg/m^2)	27.1 (3.5)
Father's occupational status	
upper middle (%)	23.7
lower middle (%)	24.8
manual worker (%)	51.5
Intellectual ability total score at military service 1952-72	27.6 (6.9)
Verbal reasoning subtest score	28.5 (8.1)
Visuospatial reasoning subtest score	25.7 (5.9)
Arithmetic reasoning subtest score	28.4 (9.1)
Physical functioning score in 2001-04	91.0 (11.4)
Physical functioning score in 2013	86.1 (17.9)

Table 2

Associations between intellectual ability in young adulthood and physical functioning at age 61 and 71 years (n=360).

	Physical functioning			Model fit	
Path	**Path coefficients**	**Std. Err.**	**p-value**	**χ^2(df=14)**	**p-value**
Total score (IA)				3.27	0.999
Direct effects					
IA→PF1	2.26	0.84	0.007		
IA→PF2	-0.05	0.87	0.956		
PF1→PF2	0.81	0.05	<0.001		
Indirect effects					
IA→PF1→PF2	1.83	0.68	0.007		
Total effects					
IA→PF2	1.78	1.11	0.107		
Arithmetic reasoning (AR)				4.97	0.986
Direct effects					
AR→PF1	2.35	0.81	0.004		
AR→PF2	-0.06	0.92	0.951		
PF1→PF2	0.82	0.05	<0.001		
Indirect effects					
AR→PF1→PF2	1.92	0.66	0.004		
Total effects					
AR→PF2	1.86	1.15	0.106		
Verbal reasoning (VR)				2.96	0.999
Direct effects					
VR→PF1	1.94	0.84	0.021		
VR→PF2	0.10	0.89	0.910		
PF1→PF2	0.81	0.05	<0.001		
Indirect effects					
VR→PF1→PF2	1.57	0.69	0.022		
Total effects					
VR→PF2	1.66	1.09	0.127		
Visuospatial reasoning (VSR)				3.02	0.999
Direct effects					
VSR→PF1	1.56	0.86	0.072		
VSR→PF2	-0.17	0.96	0.859		
PF1→PF2	0.81	0.05	<0.001		
Indirect effects					
VSR→PF1→PF2	1.26	0.71	0.073		
Total effects					
VSR→PF2	1.09	1.18	0.356		

Note. Intellectual ability / subtests and physical functioning adjusted for age at measurement, childhood SES and BMI. For all models CFI (Comparative Fit Index) = 1, TLI (Tucker Lewis Index) = 1 and RMSEA = 0 (90 % confidence interval: 0, 0).
IA= Standardized Intellectual ability test total score in 1952-72, PF1= Physical functioning in 2001-2004, PF2=Physical functioning in 2013, AR= Standardized Arithmetic reasoning test score in 1952-72, VR= Standardized Verbal reasoning test score in 1952-72, VSR= Standardized Visuospatial reasoning test score in 1952-72