Objectively measured physical activity and physical performance in old age

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Abstract

Background: Physical performance is a key factor that determines how older people cope with daily tasks and maintain independency. There is strong evidence suggesting that physical activity (PA) is important in maintaining physical performance in old age. However, most studies have been done using self-reported PA. Our aim was to explore the association between objectively measured PA and physical performance in old age.

Methods: We studied 695 participants (mean age 70.7 years, SD 2.7) from the Helsinki Birth Cohort Study. Physical performance was assessed with the Senior Fitness Test (SFT) and PA with a multisensory activity monitor Sense-Wear Pro 3 Armband.

Results: Total volume of PA was significantly associated with the overall SFT score (β 0.08, 95% confidence interval 0.07-0.10, $p<0.001$). There were no significant differences between men and women. Both light and moderate to vigorous level of PA (MVPA) were positively associated with the overall SFT score while sedentary time was negatively associated with the overall SFT score.

Conclusions: Volume of objectively measured PA among older people was positively associated with the physical performance measured with a validated fitness test battery.

Keywords: Physical activity, Physical performance, Physical functioning, Senior Fitness Test, Aging

Introduction

As life expectancy is increasing the proportion of people aged 65 years or over is growing rapidly. Physical functioning is one of the primary determinants of quality of life in old age and plays a key role in maintaining independence and activity of daily life among older people [1]. Even modest declines in functional capabilities are associated with loss of independence, institutionalization and higher healthcare needs and utilization [2]. According to the World Health Organisation (WHO), physical inactivity is the fourth leading risk factor for mortality globally [3]. Several cohort studies and randomized controlled trials have shown that physical inactivity is associated with a higher incidence of several chronic diseases including cardiovascular disease, type 2 diabetes, cancer such as colon and breast cancer and cognitive disorders [4-7].

Healthy aging can be defined as including three main components: low probability of disease and disease-related disability, high cognitive and physical functional capacity, and active engagement with life [8]. One key component in healthy aging is maintaining an adequate level of physical performance [9], which is needed to be able to successfully perform everyday activities such as personal care, housework and shopping. Rikli and Jones have developed a validated functional fitness test battery especially for older people, The Senior Fitness Test (SFT) (Rikli and Jones 2001). It incorporates aspects of strength, mobility, freedom of movement, balance and coordination which are needed to be able to perform everyday activities. Using a fitness test battery, such as the Senior Fitness Test (SFT) [10] developed especially for older people, will more likely capture the different domains of physical performance.

There is strong evidence that physical activity (PA) is an important factor needed to maintain good physical performance [11-13] and promote health ageing [14]. Although evidence on the beneficial association between PA and subsequent physical performance is accumulating, most studies have assessed PA and/or physical functioning using questionnaires and less studies have used objective validated measures of both PA and physical performance. The PA monitor used in this study represents the next generation activity monitor and has been shown to be superior to most previously used monitors [15]. The aim of this study was to assess how objectively measured PA is associated with physical performance tested with the SFT among older individuals.

Methods

Study population and measures

This study is part of the Helsinki Birth Cohort Study (HBCS) that includes 13,345 individuals born in Helsinki between 1934 and 1944. In the year 2000, a random sample of subjects from HBCS were invited to participate in a clinical examination conducted between the years 2001 and 2004 [16]. From this clinical study cohort (n=2003), 1404 people who were alive and living within 100 km distance from the study clinic in Helsinki were invited to participate in a new clinical follow-up in 2011. A total of 1094 participants attended the clinical examination between 2011 and 2013. Of these, 695 individuals (316 men and 379 women) had adequate information on both objectively measured PA and physical performance test (SFT). The clinical study protocol was approved by the Ethics Committee of Epidemiology and Public Health of the Hospital District of Helsinki and Uusimaa. Written informed consent was obtained from each participant before any study procedure was initiated.

Assessment of physical activity

PA was measured between 2012 and 2013 using the Sense-Wear Pro 3 Armband (SWA) (BodyMedia, Inc., Pittsburg, PA, USA). The SWA is a multisensory body monitor that is worn on the triceps of the right arm that measures skin temperature, near-body temperature, heat flux, galvanic skin response, and biaxial accelerations. Collected data was analyzed with Innerview Sensewear Professional Software (version 6.1). The SWA has been shown to be valid for assessing energy expenditure in free-living conditions [17] and the energy expenditure estimated by the SWA correlates strongly with estimates from doubly labelled water and indirect calorimetry also in a study performed in elderly people (*r* 0.48, *p*<0.01) [18]. The study population was instructed to wear the SWA for 10 consecutive days, also when sleeping and to take off the SWA only when showering, bathing and swimming. Participants having valid data from at least four weekdays and one weekend day were included in the analysis. SWA based PA was expressed in the metabolic equivalents of task (MET). MET values were multiplied with time (hours) to calculate MET-hours as previously reported [19]. Duration and volume of total daily PA were divided into three subcategories based on the intensity; sedentary time (ST) time (< 1.5 MET), light PA (> 1.5– < 3.0 MET) and moderate to vigorous (MVPA) (>3 MET) [20]

Physical performance

Physical performance was assessed by using the validated Senior Fitness Test battery (SFT) [10] between 2011 and 2013. We used a modified test battery consisting of five components of the SFT: number of full stands in 30 s with arms folded across chest to assess lower-body strength; number of bicep curls in 30 s while holding a hand weight (3 kg for men and 2 kg for women) to assess upper-body strength; chair sit and reach to assess the lower-body flexibility (from sitting position with leg extended at front of chair and hands reaching toward toes, number of cm (+ or −) from extended fingers to tip of toe); number of meters walked in 6 min to measure aerobic endurance; and back scratch to assess upper-body flexibility (with one hand reaching over shoulder and the other one up middle of back, distance (cm) between extended middle fingers (+ or −). All measurements were performed by a team of trained research assistants. The result of each test was expressed as age (for each 5-year group) and sex standardized percentile scores. An overall test score was calculated by summarizing the normalized scores of the five SFT components. The overall SFT score varied between 5 and 100.

Covariates

The participants were measured for weight and height between 2012 and 2013. Body mass index (BMI) was calculated as weight in kilograms divided by square of height in meters (kg/m^2). Lean body mass (LBM) and body fat was assessed with bioelectrical impedance by using the InBody 3.0 eight-polar tactile electrode system (Biospace Co., Ltd., Seoul, Korea). Participants' smoking habits and other health characteristics were assessed by questionnaires. Smoking status was expressed as years of smoking. Data on educational attainment (years of studying) was obtained from Statistics Finland by using the unique personal identification number assigned to all Finnish residents. All measurements were done by trained study nurses.

Statistical analyses

Data is expressed as means (standard deviation). We used multiple linear regression analyses to assess the association between the volume (MET-hours) of daily PA (total PA, ST, light PA, MVPA) and SFT overall score and SFT component scores (chair stand, arm curl, chair sit and reach, six min walk, back scratch). For the analysis, standardized SFT scores were calculated. The basic models were adjusted for age and sex when applicable. In model 2 further adjustments were made for smoking (years of smoking) and educational attainment (years of studying). Tests of interaction sex x PA on SFT showed that the association between PA and SFT did not vary by gender. Therefore, when analyzing the association between PA and different SFT components we pooled gender groups together. The significance level was set at $p < 0.05$. The analyses were carried out with SPSS (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp).

Results

The mean age of the participants was 70.7 years (range 66.9-79.1) when the SFT was measured. Women performed better than men and scored significantly better on the overall SFT, chair stand, arm curl, chair sit and reach test (Table 1), but no significant differences were found for the back scratch or six-minute walk test. We found no significant gender differences in time spent at sedentary level of PA, but women spent significantly more time in light level of PA compared to men, while men spent significantly more time in MVPA compared to women ($p<0.001$) (Table 1). The whole cohort spent on average 28 % of the total volume of PA in the level of light and 16 % in the level of MVPA.

From the second clinical follow up of 1094 individuals those who had data on PA (695) tended to be younger ($p=0.16$) and their lean body mass was higher ($p=0.042$) compared to those who did not take part in the study. They also succeeded significantly better in overall SFT ($p=0.001$), chair stand ($p=0.023$), arm curl ($p=0.025$) and six-minute walk ($p<0.001$) tests.

Table 2 shows the association between PA and overall SFT score by gender. The total volume of age-adjusted PA was significantly associated with overall SFT score both in men and in women ($p<0.001$). The volume of ST was negatively, while light PA and MVPA were positively associated with the overall SFT score. Further adjustment for smoking and education did not attenuate these findings. When the volume of both ST and MVPA were included into the model, MVPA, but not ST, remained significantly associated with total SFT score (data not shown).

Since there were no statistically significant differences between men and women we combined the sexes when assessing the association between the PA and the different components of SFT (Table 3). The total volume of PA was positively associated with all the SFT components. The strongest association was seen for distance walked in six minutes –component (fully adjusted β 0.09, 95% confidence interval (CI) 0.08-0.10, $p<0.001$) and the weakest association for the arm curl component (β 0.02, 95% CI 0.01-0.04, $p= 0.020$). Association between the ST, light PA and MVPA and different components of SFT are presented in *the table Appendix 4 in the supplementary data on the journal website* http://www.ageing.oxfordjournals.org/*.* The associations between different levels of PA and the SFT components were parallel with those presented for the overall SFT. Also the association between some basic characteristics and the total volume of PA and SFT sum score can be find in *the table Appendix 5 in the supplementary data on the journal website* http://www.ageing.oxfordjournals.org/. Female gender and educational attainment was positively and BMI, LBM, body fat percentage and smoking was negatively associated with SFT sum score. Age, male gender, BMI, LBM, body fat percentage and educational attainment was positively associated with total volume of PA.

Discussion

In this aging cohort, we explored the association between objectively measured PA and physical performance tested with SFT. We found that the volume of PA was significantly associated both with the overall SFT score and with all of the five test components. We also found that the volume of PA was most strongly associated with the six-minute walk test, which measures aerobic endurance. Previous studies have shown that slow gait speed is predictive of premature death and higher prevalence of disability, falls and hospitalization in older people [21]. In our study both light and moderate to vigorous level of PA was positively associated with better physical performance. On the other hand, sedentary level of PA was negatively associated with physical functioning. Several studies have shown that physical inactivity is an independent risk factor for loss of physical functioning [13]. Therefore, replacing even a small amount of ST with light PA or MVPA could bring significant health benefits.

Healthy aging is important from a public health point of view as the number of older people is growing. Physical decline may be slowed down or hindered by promoting PA among older individuals [9]. There is evidence suggesting that PA is one of the most important lifestyle factors for maintenance good health [22]. While a sedentary lifestyle is increasing and the physical reserve capacity is diminishing, many old people are functioning close to their maximum capacity when performing everyday activities. A recent study [23] showed that significant health benefits were even seen among older people who became physically active relatively late in life. There have also been trials that have shown favorable effects of exercise training interventions on physical functioning among older persons [24].

PA influences physical functioning/performance in several ways. PA improves aerobic fitness, strengthens muscles, reduces body fat, slows down the loss of bone density and improves flexibility and contributes therefore to better walking capacity, balance and decreased risk of falling and fractures. PA also reduces the risk to several diseases, such as cardiovascular diseases, type 2 diabetes, several cancers and the functional decline and related premature death [4, 25]. PA also affects positively the function of neurotransmitters and cerebral morphology and reduces cognitive disorders and depression and improves self-control and self-image and these may help older people to stay active in the community [6].

Our study has several strengths including a large study population consisting of both men and woman and a well characterized cohort. We measured the overall physical performance instead of focusing upon a single aspect of it. There have been other studies showing that PA of older people is associated with their physical performance, but these studies have used a more condensed physical fitness tests (gait speed, hand grip or Short Physical Performance Battery, SPPB) [12]. SPPB has for example been claimed to have significant “ceiling” or “floor” effects being either too easy or too difficult limiting its ability to provide measurement data on a continuous scale. SFT is specially designed for older adults and it is a validated and reliable test that measures strength, endurance, flexibility, agility and balance that are all associated with maintaining physical independence in old age and the test measures performance on a continuous scale across a wide range of functional abilities. A further strength of our study is that we measured PA objectively instead of using questionnaires that are commonly used in epidemiological studies. Questionnaires provide convenient and low-cost estimates of PA but are prone to recall bias especially in older populations e.g. due to cognitive impairments. With the use of body-worn monitoring devices the volume of PA can be measured objectively. Compared to the questionnaires they give more reliable information about the volume of PA also in older people [18]. Older adults tend to be less physically active overall and are more likely to participate in lower-intensity activities that are often poorly reported by questionnaires. The SenseWear Armband is one of the next generation activity monitors. It is a valid multiple sensor device that enables to assess accurately PA energy expenditure in free-living conditions [26] and also has the ability to capture information about frequency, intensity and duration of activity.

The present study has some limitations. Our study was cross-sectional and thus we cannot determine any direction of causality of the observed associations, i.e. it may have been possible that those who had poorer physical performance were less able to be physically active. Individuals who participated in the clinical examination in 2011–2013 were younger, thinner, more educated, and had a healthier diet in 2001–2004 compared with those who did not participate in the follow-up [27]. The study population lived in a restricted geographic area in Finland and therefore participants may not be fully representative of all older people living in Finland or people living elsewhere. The study included Caucasians only, which might limit generalizability of our results to other ethnic groups. Even though we were able to adjust for potential cofounders including smoking and educational attainment, we cannot exclude the possibility of residual confounding caused by other unmeasured covariates. Participating in the SFT required a certain level of physical fitness why cohort members with severe functional limitations were excluded from the study. Our study may also be limited by the “volunteer effect”, because not everyone from the original cohort was willing to use the activity monitor. Those who participated in the PA measurement had significantly better overall SFT results and also succeeded better in other test components than chair sit and reach and back scratch (data not shown).

In conclusion, the findings of the present study showed a strong association between sedentary time and total PA and different components of physical performance assessed by the senior fitness test. These associations were similar in men and women. The presented results were based on the accurate measures of both PA and physical performance, which can be costly and time-consuming. Thus, their feasibility in large population studies and practical settings may be limited. However, we have reported a strong positive association between PA and its subcategories and physical performance among older people. Thus, it is possible that promoting PA among older people should be prioritized in future to enable independent life and compression of morbidity. In this cross-sectional study we were unable to define causal relationships between the PA and physical performance, however, it is possible that promoting PA among older people can support independent life due to the better physical fitness. Future prospective studies are, however, required to clarify causal relationships between the PA and physical performance among older people.

Key points:

- Objectively measured total daily physical activity in older people was positively associated with physical performance tested with SFT.
- Both light PA and MVPA were positively associated with the overall SFT score.
- The volume of physical activity was most strongly associated with the six-minute walk test component of SFT.

References

1. Geirsdottir OG, Arnarson A, Briem K, Ramel A, Tomasson K, Jonsson PV, et al. Physical function predicts improvement in quality of life in elderly Icelanders after 12 weeks of resistance exercise. J Nutr Health Aging. 2012 Jan;16(1):62-6.

2. Fried LP, Guralnik JM. Disability in older adults: evidence regarding significance, etiology, and risk. J Am Geriatr Soc. 1997 Jan;45(1):92-100.

3. WHO. Global recommendations on physical activity for health. . 2010:7.

4. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet. 2012 Jul 21;380(9838):219-29.

5. Hamer M, Stamatakis E. Low-dose physical activity attenuates cardiovascular disease mortality in men and women with clustered metabolic risk factors. Circ Cardiovasc Qual Outcomes. 2012 Jul 1;5(4):494-9.

6. Middleton LE, Barnes DE, Lui LY, Yaffe K. Physical activity over the life course and its association with cognitive performance and impairment in old age. J Am Geriatr Soc. 2010 Jul;58(7):1322-6.

7. Peels DA, Hoogenveen RR, Feenstra TL, Golsteijn RH, Bolman C, Mudde AN, et al. Long-term health outcomes and cost-effectiveness of a computer-tailored physical activity intervention among people aged over fifty: modelling the results of a randomized controlled trial. BMC Public Health. 2014 Oct 23;14:1099,2458-14-1099.

8. Rowe JW, Kahn RL. Successful aging. Gerontologist. 1997 Aug;37(4):433-40.

9. Paterson DH, Warburton DE. Physical activity and functional limitations in older adults: a systematic review related to Canada's Physical Activity Guidelines. Int J Behav Nutr Phys Act. 2010 May 11;7:38,5868-7-38.

10. Rikli RE, Jones JC. Development and Validation of a Functional Fitness Test for Community-Residing Older Adults. . Journal of Aging and Physical Activity. 1999;7(2):129,-161.

11. Cooper R, Kuh D, Cooper C, Gale CR, Lawlor DA, Matthews F, et al. Objective measures of physical capability and subsequent health: a systematic review. Age Ageing. 2011 Jan;40(1):14-23.

12. Patel KV, Coppin AK, Manini TM, Lauretani F, Bandinelli S, Ferrucci L, et al. Midlife physical activity and mobility in older age: The InCHIANTI study. Am J Prev Med. 2006 Sep;31(3):217-24.

13. Pluijm SM, Visser M, Puts MT, Dik MG, Schalk BW, van Schoor NM, et al. Unhealthy lifestyles during the life course: association with physical decline in late life. Aging Clin Exp Res. 2007 Feb;19(1):75-83.

14. Gulsvik AK, Thelle DS, Samuelsen SO, Myrstad M, Mowe M, Wyller TB. Ageing, physical activity and mortality--a 42-year follow-up study. Int J Epidemiol. 2012 Apr;41(2):521-30.

15. Almeida GJ, Wert DM, Brower KS, Piva SR. Validity of physical activity measures in individuals after total knee arthroplasty. Arch Phys Med Rehabil. 2015 Mar;96(3):524-31.

16. Eriksson JG, Osmond C, Kajantie E, Forsen TJ, Barker DJ. Patterns of growth among children who later develop type 2 diabetes or its risk factors. Diabetologia. 2006 Dec;49(12):2853-8.

17. St-Onge M, Mignault D, Allison DB, Rabasa-Lhoret R. Evaluation of a portable device to measure daily energy expenditure in free-living adults. Am J Clin Nutr. 2007 Mar;85(3):742-9.

18. Colbert LH, Matthews CE, Havighurst TC, Kim K, Schoeller DA. Comparative validity of physical activity measures in older adults. Med Sci Sports Exerc. 2011 May;43(5):867-76.

19. Wasenius N, Venojarvi M, Manderoos S, Surakka J, Lindholm H, Heinonen OJ, et al. Unfavorable influence of structured exercise program on total leisure-time physical activity. Scand J Med Sci Sports. 2014 Apr;24(2):404-13.

20. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc. 2000 Sep;32(9 Suppl):S498-504.

21. Pamoukdjian F, Paillaud E, Zelek L, Laurent M, Levy V, Landre T, et al. Measurement of gait speed in older adults to identify complications associated with frailty: A systematic review. J Geriatr Oncol. 2015 Nov;6(6):484-96.

22. Svantesson U, Jones J, Wolbert K, Alricsson M. Impact of Physical Activity on the Self-Perceived Quality of Life in Non-Frail Older Adults. J Clin Med Res. 2015 Aug;7(8):585-93.

23. Hamer M, Lavoie KL, Bacon SL. Taking up physical activity in later life and healthy ageing: the English longitudinal study of ageing. Br J Sports Med. 2014 Feb;48(3):239-43.

24. Gudlaugsson J, Gudnason V, Aspelund T, Siggeirsdottir K, Olafsdottir AS, Jonsson PV, et al. Effects of a 6-month multimodal training intervention on retention of functional fitness in older adults: a randomized-controlled cross-over design. Int J Behav Nutr Phys Act. 2012 Sep 10;9:107,5868-9-107.

25. Newman AB, Simonsick EM, Naydeck BL, Boudreau RM, Kritchevsky SB, Nevitt MC, et al. Association of long-distance corridor walk performance with mortality, cardiovascular disease, mobility limitation, and disability. JAMA. 2006 May 3;295(17):2018-26.

26. Fruin ML, Rankin JW. Validity of a multi-sensor armband in estimating rest and exercise energy expenditure. Med Sci Sports Exerc. 2004 Jun;36(6):1063-9.

27. Perala MM, von Bonsdorff M, Mannisto S, Salonen MK, Simonen M, Kanerva N, et al. A healthy Nordic diet and physical performance in old age: findings from the longitudinal Helsinki Birth Cohort Study. Br J Nutr. 2016 Jan 20:1-9.

Table 1 Subjects' characteristics, SFT results and the volume and duration of objectively measured physical activity.

	Total (*N=695*)		Men (*N=316*)		Women (*N=379*)		
Characteristics	Mean	SD	Mean	SD	Mean	SD	p^{a}
Age (years)	70.7	2.7	70.6	2.6	70.8	2.7	0.311
Weight (kg)	76.9	14.1	83.3	13.0	71.6	12.7	<0.001
Height (cm)	168.7	9.1	176.3	6.1	162.4	5.7	<0.001
Body mass index (kg/m2)	27.0	4.4	26.8	3.8	27.2	4.8	0.242
Lean body mass (kg)	54.0	10.8	63.5	7.6	46.1	5.3	<0.001
Body fat (%)	29.6	8.5	23.3	5.9	34.8	6.7	<0.001
Smoking (years)	11.3	16.5	15.5	17.7	7.8	14.6	<0.001
Years of fulltime studying	12.6	3.6	12.9	3.8	12.3	3.4	0.024
SFT test results							
Sum Score (Contains 5 test)	46.4	17.5	43.7	16.8	48.7	17.8	<0.001
Chair stand test result (n)	11.5	2.3	11.9	2.2	11.1	2.3	
Chair stand percentiles	31.7	18.3	29.3	15.7	33.6	20.1	0.002
ArmCurl test result (n)	16.0	3.5	17.2	3.6	15.0	3.1	
ArmCurl percentiles	50.4	23.7	47.2	23.4	53.1	23.6	<0.001
Chair sit and reach test result (cm)	0.5	4.9	-2.6	4.9	1.3	4.1	
Chair sit and reach percentiles	45.2	29.8	38.1	28.6	51.1	29.6	<0.001
Six min walk test result (m)	584.8	103.6	621.5	101.5	554.3	95.2	
Six min walk percentiles	54.8	27.1	55.6	27.6	54.2	26.8	0.503
Back scratch test result (cm)	-3.4	4.8	-5.2	5.1	-1.9	3.9	
Back scratch percentiles	50.1	29.4	48.2	29.9	51.7	28.9	0.118
Volume of PA (METmin/d)							
Total Volume	1779.6	298.5	1831.4	266.9	1736.3	316.4	<0.001
Volume of ST	987.3	82.4	1013.8	76.8	965.2	80.5	<0.001
Volume of light PA	496.7	181.6	476.9	157.8	513.1	198.0	0.009
Volume of MVPA	295.6	230.0	340.7	240.1	258.0	214.5	<0.001
Duration of PA (min/d)							
Duration of ST	1137.1	105.1	1138.9	95.9	1135.6	112.4	0.680
Duration of light PA	227.0	76.5	214.1	66.3	237.8	82.7	<0.001
Duration of MVPA	76.2	57.3	87.2	58.4	67.0	54.8	<0.001
Average wear time of SWA (min/d)	1436.8	6.0	1435.9	6.1	1437.6	6.0	

[a]Difference between men and women

Abbreviations: SD, standard deviation; MET, metabolic equivalents of task; ST, sedentary time; MVPA, moderate to vigorous physical activity

Table 2 The association between objectively measured total volume of physical activity and Senior Fitness Test.

	Total (*N*=695)		Men (*N*=316)		Women (*N*=379)	
The volume of PA	β (95 % CI)	*p*	β (95 % CI)	*p*	β (95 % CI)	*p*
Model 1[a]						
Total volume (METh/d)	0.08 (0.07 to 0.10)	<0.001	0.08 (0.06 to 0.10)	<0.001	0.09 (0.07 to 0.10)	<0.001
Volume of ST (METh/d)	-0.12 (-0.18 to -0.07)	<0.001	-0.14 (-0.22 to -0.05)	0.001	-0.11 (-0.19 to -0.04)	0.004
Volume of light PA (METh/d)	0.09 (0.07 to 0.12)	<0.001	0.07 (0.03 to 0.11)	0.001	0.11 (0.08 to 0.14)	<0.001
Volume of MVPA (METh/d)	0.10 (0.08 to 0.11)	<0.001	0.08 (0.06 to 0.11)	<0.001	0.11 (0.09 to 0.14)	<0.001
Model 2[b]						
Total volume (METh/d)	0.08 (0.06 to 0.09)	<0.001	0.07 (0.05 to 0.09)	<0.001	0.08 (0.06 to 0.10)	<0.001
Volume of ST (METh/d)	-0.10 (-0.16 to -0.05)	<0.001	-0.12 (-0.20 to -0.04)	<0.001	-0.08 (-0.16 to -0.01)	0.037
Volume of light PA (METh/d)	0.08 (0.06 to 0.11)	<0.001	0.05 (0.01 to 0.09)	0.009	0.10 (0.07 to 0.13)	<0.001
Volume of MVPA (METh/d)	0.09 (0.07 to 0.11)	<0.001	0.07 (0.05 to 0.10)	<0.001	0.10 (0.08 to 0.13)	<0.001

[a]Model 1: Multiple linear regression adjusted for age and (sex)

[b]Model 2 Multiple linear regression adjusted for age, (sex), smoking and educational attainment

Abbreviations: PA, physical activity; β, regression coefficient; CI, confidence interval; MET, metabolic equivalents of task; ST, sedentary time; MVPA, moderate to vigorous physical activity

Table 3 The association between the volume of total physical activity and the different components of Senior Fitness Test (SFT).

Standardized	Model 1[a]		Model 2[b]	
SFT component	β (95 % CI)	*p*	β (95 % CI)	*p*
Chair Stand	0.06 (0.05 to 0.07)	<0.001	0.05 (0.04 to 0.07)	<0.001
ArmCurl	0.02 (0.01 to 0.04)	0.020	0.02 (0.00 to 0.03)	0.021
ChairSitandReach	0.03 (0.02 to 0.05)	<0.001	0.03 (0.02 to 0.05)	<0.001
SixminWalk	0.09 (0.08 to 0.10)	<0.001	0.09 (0.08 to 0.1)	<0.001
BackScratch	0.05 (0.04 to 0.07)	<0.001	0.05 (0.04 to 0.07)	<0.001

[a]Model 1: Multiple linear regression adjusted for age and sex

[b]Model 2: Multiple linear regression adjusted for age, sex, smoking and educational attainment

Abbreviations: β, regression coefficient; CI, confidence interval

Table 4s The association between the objectively measured total physical activity and the different components of Senior Fitness Test.

The volume of PA	Chair Stand β (95 % CI)	p	Arm Curl β (95 % CI)	p	Chair Sit and Reach β (95 % *CI*)	p	Six minute walk test β (95 % CI)	p	Back Scratch β (95 % CI)	p
Model 1[a]										
Total volume (METh/d)	0.06 (0.05 to 0.07)	<0.001	0.02 (0.01 to 0.04)	0.020	0.03 (0.02 to 0.05)	<0.001	0.09 (0.08 to 0.10)	<0.001	0.05 (0.04 to 0.07)	<0.001
Volume of ST (METh/d)	-0.18 (-0.23 to -0.13)	<0.001	-0.12 (-0.17 to -0.07)	<0.001	-0.05 (-0.10 to 0.01)	0.078	-0.15 (-0.20 to -0.10)	<0.001	0.04 (-0.01 to 0.09)	0.145
Volume of light PA (METh/d)	0.09 (0.06 to 0.11)	<0.001	0.03 (0.00 to 0.05)	0.031	0.03 (0.01 to 0.06)	0.004	0.11 (0.08 to 0.13)	<0.001	0.05 (0.03 to 0.08)	<0.001
Volume of MVPA (METh/d)	0.07 (0.05 to 0.09)	<0.001	0.04 (0.02 to 0.06)	<0.001	0.04 (0.02 to 0.06)	<0.001	0.11 (0.09 to 0.12)	<0.001	0.05 (0.03 to 0.07)	<0.001
Model 2[b]										
Total volume (METh/d)	0.05 (0.04 to 0.07)	<0.001	0.02 (0.00 to 0.03)	0.021	0.03 (0.02 to 0.05)	<0.001	0.09 (0.08 to 0.1)	<0.001	0.05 (0.04 to 0.07)	<0.001
Volume of ST (METh/d)	-0.16 (-0.22 to -0.11)	<0.001	-0.10 (-0.16 to 0.05)	<0.001	-0.04 (-0.09 to 0.01)	0.127	-0.13 (-0.18 to -0.08)	<0.001	0.05 (-0.01 to 0.10)	0.086
Volume of light PA (METh/d)	0.08 (0.06 to 0.10)	<0.001	0.02 (-0.00 to 0.04)	0.101	0.03 (0.01 to 0.05)	0.011	0.10 (0.08 to 0.12)	<0.001	0.05 (0.03 to 0.07)	<0.001
Volume of MVPA (METh/d)	0.06 (0.04 to 0.08)	<0.001	0.03 (0.01 to 0.05)	0.002	0.04 (0.02 to 0.06)	<0.001	0.10 (0.08 to 0.12)	<0.001	0.05 (0.03 to 0.07)	<0.001

The component of Senior Fitness test were standardized before the analyses.

[a]Model 1: Multiple linear regression adjusted for age and sex

[b]Model 2: Multiple linear regression adjusted for age, sex, smoking and educational attainment

Abbreviations: PA, physical activity; β, regression coefficient; CI, confidence interval; MET, metabolic equivalents of task; ST, sedentary time; MVPA, moderate to vigorous physical activity

Table 5s The association between basic characteristics and the volume of total physical activity and Senior Fitness Test sum score.

Characteristics	Volume of total physical activity β (95 % CI)	*p*	SFT sum score β (95 % CI)	*p*
Age (years)	-0.12 (-0.37 to -0.09)	0.001	0.03 (-0.33 to 0.66)	0.506
Sex	-0.16 (-2.32 to -0.85)	<0.001	0.14 (2.41 to 7.60)	<0.001
Body mass index (kg/m2)	-0.65 (-0.81 to -0.68)	<0.001	-0.34 (-1.66 to -1.10)	<0.001
Lean body mass (kg)	-0.06 (-0.06 to 0.01)	0.116	-0.14 (-0.35 to -0.11)	<0.001
Body fat (%)	-0.60 (-0.38 to -0.31)	<0.001	-0.22 (-0.60 to -0.30)	<0.001
Smoking (years)	-0.03 (-0.03 to 0.01)	0.398	-0.21 (-0.30 to -0.14)	<0.001
Years of fulltime studying	0.01 (0.03 to 0.23)	0.013	0.18 (0.53 to 1.24)	<0.001

Abbreviations: β, regression coefficient; CI, confidence