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Physical activity types and life expectancy with and without cardiovascular disease: the Rotterdam Study

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ABSTRACT

Background We aimed to determine the contribution of specific physical activity (PA) types (i.e. walking, cycling, domestic work, sports and gardening) on total life expectancy (LE) and LE with and without cardiovascular disease (CVD).

Methods We constructed multistate life tables to calculate the effects of total PA and PA types on LE, among individuals older than 55 years from the Rotterdam Study. For the life table calculations, we used sex-specific prevalences, incident rates and hazard ratios for three transitions (healthy-to-CVD, healthy-to-death and CVD-to-death) by levels of PA and adjusted for confounders.

Results High total PA was associated with gains in total and CVD-free LE. High cycling contributed to higher total LE in men (3.7 years) and women (2.1 years) and higher LE without CVD in men (3.1 years) and women (2.4 years). Total and CVD-free LE were increased by high domestic work in women (2.6 and 2.4 years, respectively) and high gardening in men (2.7 and 2.0 years, respectively).

Conclusions Higher PA levels are associated with increased LE and more years lived without CVD. Of the different PA types, cycling provided high effects in both men and women. Cycling could be more strongly encouraged in activity guidelines to maximize the population benefits of PA.

Keywords circulatory disease, epidemiology, physical activity

Introduction

The association between physical activity (PA) and reduced risk of mortality and cardiovascular disease (CVD) has been well-documented.[1,2] According to a recent meta-analysis, regular PA of moderate to vigorous intensity may contribute to up to 27% reduced risk of CVD and mortality.[3] However, to provide comprehensive information for public and individual healthcare planning, it could be informative to look beyond hazard ratios and to provide measures of the lifetime consequences of PA. Additionally, since individuals with CVD have a reduced quality of life,[4,5] information on the life years with and without CVD is of relevance.

Previous studies evaluating the association between PA and LE have shown that compared to individuals with low

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levels of PA, high levels of PA in adulthood are associated with an increase in LE of 1.8–4.2 years.[6–8] Two studies within the Framingham Heart Study both showed that at the age of 50 years, high levels of PA not only increased total LE, but also increased the number of years lived without CVD.[9,10] However, these studies started data collection in the end of the 20th century, whereas treatment for cardiovascular risk factors has improved after 1990, resulting in the reduction of cardiovascular incidence and mortality rates.[11] Additionally, previous studies have evaluated the effect of total or leisure time PA, whereas it remains unclear whether specific PA types contribute most to the beneficial effects of PA in middle-aged and elderly adults. It is important to distinguish and to measure the independent effect of different types of PA (e.g. cycling, walking, domestic work) on LE, to be able to make clear and effective public health recommendations.

Therefore, we aimed to evaluate the impact of total PA and PA types on the average years lived with and without CVD at age 55 years or older. Using data from the Rotterdam study, we constructed multistate life tables from data collected starting in the year 2000 and with over 10 years of follow-up.

Methods

Study population

This study was embedded within the Rotterdam Study, a prospective population-based cohort study among subjects aged ≥55 years in Rotterdam, the Netherlands. Baseline examinations were completed between 1990 and 1993. In 2000–01, the Rotterdam Study was extended with 3011 participants who had become ≥55 years old or had moved into the study district. The objectives and design of the Rotterdam Study have been described in detail elsewhere.[12]

For the current study, we used data from 7808 participants attending the third examination of the original cohort (RS-I-3, between 1997 and 1999; $n = 4797$) and the participants attending the first examination of the extended cohort (RS-II-1, between 2000 and 2001; $n = 3011$). Of this combined total, 7310 participants completed PA collection (see Supplementary Fig. S1). Subsequently, we excluded participants without informed consent ($n = 52$) or without information regarding CVD ($n = 4$). After exclusion, 7254 participants (4207 women) were available for the current analysis. Baseline information was collected through home interviews or was measured at the study centre visit as described previously.[13,14] Information regarding the measurement of risk factors is provided as online Supplementary Material.

PA assessment

Participants were asked how many hours per week they spent in walking, cycling, sports, gardening and domestic work in the past year, using an adapted version of the Zutphen Physical Activity Questionnaire.[15,16] We used metabolic equivalent of task (MET) to quantify the intensity of activity. MET values were assigned to every activity, according to the 2011 updated version of the Compendium of Physical Activities.[17] Sports that were not in this compendium and to which we could not assign a MET value (e.g. under water hockey, 'revalidation sports') were not used in the analyses ($n = 33$; 2.8%). MET values of physical activities were multiplied with time (in hours) per week spent in that specific activity to calculate MET·hours·week^{-1} in total PA and in every type of PA (cycling, walking, sports, domestic work, gardening). Further detail on the assessment of PA can be found elsewhere.[18]

Finally, all PA variables were categorized into tertiles. For activities not practiced by >60% of the population (cycling, gardening, sports), the bottom category for PA levels was no participation and the remaining two categories were divided by using the median value.

Assessment of outcome

The main outcome measure under study was incident nonfatal or fatal CVD and overall mortality. CVD is defined as the presence of one or more definite manifestation of coronary heart disease (coronary revascularization or non-fatal or fatal myocardial infarction or death due to coronary heart disease), stroke and heart failure.[17,19,20] Information about cause and circumstances of death was obtained from general practitioner medical records and from municipal records. The follow-up was complete until 1 January 2010.

Data analysis

To calculate LE with and without CVD, we built multistate life tables for participants with low, medium and high levels of total PA and every PA type. We included three health states: 'free of CVD', 'history of CVD' and 'death'. The possible transitions were from free of CVD to CVD, from free of CVD to death and from history of CVD to death. Backflows were not allowed, and only the first entry into a state was considered.[9,21]

In order to assess the differences in risk of mortality and CVD among individuals 55 years and older by different categories of PA at baseline, we first calculated the overall sex- and age-specific rates for each transition. Following, we calculated the prevalence of low, medium and high PA, for every PA variable, by sex, 10-year age groups, and for individuals with and without CVD separately. Subsequently,

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gender-specific hazard ratios (HRs) comparing high and medium PA categories to low PA for each PA variable were calculated using Poisson regression ('Gompertz' distribution) in three models.[9,19] Model 1 was adjusted for age; Model 2 was additionally adjusted for smoking status, alcohol consumption in tertiles, education, marital status, cancer prevalence and the other PA types; Model 3 was additionally adjusted for body mass index, total and high-density lipoprotein cholesterol, diabetes, lipid reducing agents and antihypertensive medication. Additionally, we repeated the analyses in the total population, in which we adjusted for sex in Model 1–3.

Finally, we calculated three sets of transitions rates for each PA variable separately using the (i) overall sex-specific transition rates, the (ii) adjusted HRs (Model 2) for CVD and mortality and the (iii) prevalence of PA by gender and absence or presence of CVD. Comparable calculations have been previously described.[9,19] The multistate life table was started at age 55 years and was closed at age 100 years.

Confidence intervals for all life expectancies and differences in LE were calculated using @RISK software (Anonymous 2000; MathSoft Inc, Cambridge, MA), by Monte Carlo simulation (parametric bootstrapping) 10 000 runs.[21,22]

In a sensitivity analysis, to exclude potential bias caused by disease, we estimated the life expectancy (LE) among participants without diabetes, hypertension and dyslipidemia at baseline ($n = 4049$) for the three categories of total PA.

Missing values for covariates (<15%) were imputed using single imputation with the Expectation Maximization method in SPSS (IBM SPSS Statistical for Windows, Armonk, New York: IBM Corp).

We used STATA version 13 for Windows (StataCorp, College Station) and R statistical software (A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria) for our analysis.

Ethics approval

The Rotterdam Study has been approved by the institutional review board (medical ethics committee) of the Erasmus Medical Center and by the medical ethics committee according to the Wet Bevolkingsonderzoek ERGO (Population Study Act Rotterdam Study), executed by the Ministry of Health, Welfare and Sports of the Netherlands.

Results

We observed 1156 (19.3%) incident CVD events and 2363 (32.6%) overall deaths over 10 years of follow-up. Compared to women, men were slightly younger, smoked more and showed lower levels of BMI and total PA levels (Table 1). Individuals not completing PA data collection were slightly older and more often female, compared to individuals included in the study.

HRs of men and women were very similar. Therefore, Table 2 presents the HRs and 95% confidence interval (95% CI) for the total population, for Model 2. Additional adjustment for biological risk factors in Model 3 only slightly

Table 1 Baseline characteristics of study population ($n = 7254$)

	Men	*Women*
Participants	3047 (42.0%)	4207 (58.0%)
Demographic factors		
Age	69.3 (8.1)	70.7 (8.9)
Educational level		
Elementary	297 (9.7%)	782 (18.6%)
Lower secondary	933 (30.6%)	2212 (52.6%)
Higher secondary	1175 (38.6%)	938 (22.3%)
Tertiary	642 (21.1%)	275 (6.5%)
Marital status		
Single	87 (2.9%)	294 (7.0%)
Married	2404 (78.9%)	2142 (50.9%)
Widowed	347 (11.4%)	1363 (32.4%)
Divorced/separated	209 (6.9%)	408 (9.7%)
Physical activity		
Total PA, METhours/week	71.0 (43.2)	88.0 (43.8)
Walking, METhours/week	26.9 (23.4)	27.8 (25.3)
Cycling, METhours/week	10.5 (14.5)	7.0 (12.0)
Domestic work, METhours/week	21.2 (17.8)	46.4 (21.7)
Sports, METhours/week	7.2 (15.4)	4.0 (9.5)
Gardening, METhours/week	5.2 (11.9)	2.8 (6.6)
Lifestyle factors		
Smoking		
Never	909 (29.8)	2558 (60.8)
Former	1569 (51.5)	927 (22.0)
Current	569 (18.7)	722 (17.2)
BMI, kg/m^2	26.5 (3.2)	27.4 (4.2)
Alcohol		
Low	618 (20.3%)	1827 (43.4%)
Medium	974 (32.0%)	1487 (35.3%)
High	1455 (47.8%)	893 (21.2%)
Biological risk factors		
Using blood pressure medication	707 (23.2%)	1143 (27.2%)
Using lipid reducing agents	412 (13.5%)	486 (11.6%)
Cholesterol, mg/dl	5.5 (1.0)	6.0 (1.0)
HDL-cholesterol, mg/dl	1.2 (0.3)	1.5 (0.4)
Glucose, mg/dl	6.2 (1.7)	6.0 (1.6)
Systolic blood pressure, mm HG	144.4 (21.2)	143.8 (21.7)
Prevalent diabetes	534 (17.5%)	661 (15.7%)

Values are mean (SD) or number (percentage).

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Table 2 Hazard ratios for the different transitions for men and women, based on the Rotterdam Study

		No CVD to CVD	*No CVD to death*	*CVD to death*
Number of events		1156	1569	1136
Person-years		45 219	54 715	13 641
	Median (Range) (MET-hours per week)	*Model 2[a] HR (95% CI)*	*Model 2[a] HR (95% CI)*	*Model 2[a] HR (95% CI)*
Total PA[b]				
Low	38.5 (≤57.6)	1 [ref]	1 [ref]	1 [ref]
Moderate	74.3 (57.7–94.0)	0.93 (0.81, 1.07)	0.76 (0.68, 0.86)	0.86 (0.75, 0.99)
High	123.2 (≥94.1)	0.73 (0.63, 0.85)	0.66 (0.58, 0.75)	0.73 (0.62, 0.86)
P for trend		<0.001	<0.001	<0.001
Walking[c]				
Low	8.3 (≤13.5)	1 [ref]	1 [ref]	1 [ref]
Moderate	21.0 (13.6–30.0)	0.89 (0.77, 1.02)	0.88 (0.79, 1.00)	0.85 (0.73, 0.98)
High	49.5 (≥30.1)	0.86 (0.74, 1.00)	0.90 (0.79, 1.02)	0.87 (0.75, 1.01)
P for trend		0.05	0.09	0.05
Cycling[d]				
Low	0.0 (0.0)	1 [ref]	1 [ref]	1 [ref]
Moderate	6.0 (≤12.0)	0.85 (0.74, 0.99)	0.71 (0.62, 0.81)	0.85 (0.73, 1.00)
High	24.0 (≥12.1)	0.77 (0.65, 0.91)	0.65 (0.56, 0.76)	0.76 (0.63, 0.93)
P for trend		0.002	<0.001	0.004
Domestic work[e]				
Low	11.6 (≤22.5)	1 [ref]	1 [ref]	1 [ref]
Moderate	34.1 (22.6–44.7)	0.93 (0.80, 1.09)	0.83 (0.73, 0.94)	0.94 (0.82, 1.09)
High	57.8 (≥44.8)	0.85 (0.71, 1.01)	0.73 (0.63, 0.85)	0.88 (0.74, 1.05)
P for trend		0.06	<0.001	0.15
Sports[f]				
Low	0.0 (0.0)	1 [ref]	1 [ref]	1 [ref]
Moderate	5.4 (≤6.0)	0.80 (0.68, 0.95)	0.79 (0.68, 0.91)	0.81 (0.67, 0.97)
High	19.2 (≥6.1)	1.06 (0.90, 1.26)	0.86 (0.73, 1.00)	0.85 (0.70, 1.03)
P for trend		0.87	0.005	0.02
Gardening[g]				
Low	0.0 (0.0)	1 [ref]	1 [ref]	1 [ref]
Moderate	4.0 (≤9.2)	0.89 (0.76, 1.04)	0.75 (0.65, 0.87)	0.87 (0.72, 1.05)
High	14.0 (≥9.3)	0.98 (0.82, 1.18)	0.73 (0.62, 0.87)	0.94 (0.77, 1.15)
P for trend		0.53	<0.001	0.28

CI, confidence interval; CVD, cardiovascular disease; HR, hazard ratio; PA, physical activity; ref, referent.

[a]Model 2 was adjusted for age, sex smoking status, alcohol consumption in tertiles, education, marital status and cancer prevalence. For PA types, Model 2 was also adjusted for all other PA types.

[b]Total PA is composed of all PA types and thus of different METs. In this regard, the median levels of total PA across categories are equivalent to 1.4, 2.7 and 4.4 hours per day of moderate PA equivalent of four METs.

[c]Walking is equivalent to 3.0 METs. The median levels of walking across categories are therefore equivalent to 24, 60 and 141 minutes per day of walking.

[d]Cycling is equivalent to 4.0 METs. The median levels of cycling across categories are therefore equivalent to 0, 13 and 51 minutes per day of cycling.

[e]Average domestic work is equivalent to 3.5 METs.[23] The median levels of domestic work across categories are therefore equivalent to 28, 83 and 142 minutes per day of domestic work.

[f]Average sports is equivalent to 5.5 METs. The median levels of sports across categories are therefore equivalent to 0, 8 and 30 minutes per day of sports.

[g]Gardening is equivalent to 4.0 METs. The median levels of gardening across categories are therefore equivalent to 0, 9 and 30 minutes per day of gardening.

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Table 3 Total life expectancy (total LE), life expectancy without CVD (LE without CVD) and life expectancy with CVD (LE with CVD), and difference, in Years at Age 55, for men and women[a]

	Total LE (years)	*Dif Total LE (years)*[b]	*LE free of CVD (years)*	*Dif LE free of CVD (years)*[b]	*LE with CVD (years)*	*Dif LE with CVD (years)*[b]
Men						
Total PA						
Low	24.9 (24.6, 25.2)	Ref	20.0 (19.6, 20.4)	Ref	4.9 (4.6, 5.2)	Ref
Moderate	27.1 (26.5, 27.7)	2.2 (1.5, 2.9)	21.3 (20.6, 22.1)	1.3 (0.4, 2.3)	5.8 (5.2, 6.5)	0.9 (0.1, 1.7)
High	28.4 (27.7, 29.0)	3.5 (2.8, 4.2)	23.3 (22.5, 24.1)	3.3 (2.5, 4.2)	5.1 (4.5, 5.7)	0.2 (−0.5, 0.8)
Walking						
Low	25.4 (24.9, 25.8)	Ref	20.3 (19.8, 20.8)	Ref	5.1 (4.7, 5.4)	Ref
Moderate	26.7 (26.1, 27.4)	1.3 (0.6, 2.1)	21.3 (20.6, 22.0)	1.0 (0.1, 1.9)	5.5 (4.9, 6.1)	0.4 (−0.4, 1.2)
High	26.7 (26.0, 27.4)	1.3 (0.5, 2.1)	21.8 (21.0, 22.6)	1.5 (0.5, 2.5)	4.9 (4.3, 5.5)	−0.2 (−0.9, 0.6)
Cycling						
Low	24.7 (24.4, 25.0)	Ref	19.8 (19.4, 20.3)	Ref	4.9 (4.6, 5.2)	Ref
Moderate	26.8 (26.3, 27.4)	2.1 (1.4, 2.9)	21.2 (20.5, 21.9)	1.4 (0.4, 2.4)	5.6 (5.1, 6.3)	0.7 (0.0, 1.6)
High	28.4 (27.7, 29.0)	3.7 (3.0, 4.4)	22.9 (22.1, 23.7)	3.1 (2.1, 4.0)	5.5 (4.8, 6.2)	0.6 (−0.2, 1.3)
Domestic work						
Low	25.7 (25.4, 26.0)	Ref	20.6 (20.3, 21.0)	Ref	5.1 (4.8, 5.4)	Ref
Moderate	27.0 (26.4, 27.6)	1.3 (0.5, 2.0)	21.9 (21.2, 22.7)	1.3 (0.4, 2.2)	5.1 (4.5, 5.6)	0.0 (−0.8, 0.7)
High	26.8 (25.7, 27.9)	1.1 (−0.1, 2.2)	21.6 (20.3, 22.9)	1.0 (−0.5, 2.4)	5.2 (4.2, 6.3)	0.1 (−1.0, 1.3)
Sports						
Low	25.6 (25.3, 25.9)	Ref	20.8 (20.4, 21.2)	Ref	4.8 (4.5, 5.1)	Ref
Moderate	28.7 (27.9, 29.5)	3.1 (2.3, 4.0)	23.7 (22.7, 24.7)	2.9 (1.8, 4.0)	5.0 (4.3, 5.8)	0.2 (−0.6, 1.0)
High	26.8 (26.1, 27.6)	1.2 (0.4, 2.1)	20.5 (19.5, 21.5)	−0.3 (−1.6, 0.9)	6.4 (5.5, 7.2)	1.6 (0.5, 2.6)
Gardening						
Low	25.2 (25.0, 25.5)	Ref	20.2 (19.8, 20.5)	Ref	5.1 (4.8, 5.3)	Ref
Moderate	27.9 (27.2, 28.6)	2.7 (1.9, 3.4)	22.6 (21.8, 23.4)	2.4 (1.5, 3.4)	5.3 (4.6, 6.0)	0.2 (−0.5, 1.0)
High	27.9 (27.2, 28.7)	2.7 (1.9, 3.5)	22.2 (21.2, 23.2)	2.0 (0.8, 3.1)	5.8 (5.0, 6.6)	0.7 (−0.2, 1.6)
Women						
Total PA						
Low	28.9 (28.6, 29.3)	Ref	24.5 (24.1, 24.9)	Ref	4.5 (4.2, 4.8)	Ref
Moderate	30.4 (29.9, 30.9)	1.5 (0.8, 2.1)	25.8 (25.2, 26.4)	1.3 (0.5, 2.1)	4.6 (4.2, 5.1)	0.1 (−0.4, 0.8)
High	31.9 (31.3, 32.4)	3.0 (2.3, 3.5)	27.3 (26.7, 27.9)	2.8 (2.2, 3.6)	4.5 (4.0, 5.0)	0.0 (−0.5, 0.6)
Walking						
Low	29.8 (29.4, 30.1)	Ref	25.3 (24.9, 25.8)	Ref	4.4 (4.2, 4.7)	Ref
Moderate	30.6 (30.1, 31.2)	0.8 (0.2, 1.5)	26.3 (25.7, 26.9)	1.0 (0.2, 1.7)	4.3 (3.9, 4.8)	−0.1 (−0.7, 0.5)
High	30.5 (29.9, 31.2)	0.7 (0.0, 1.5)	26.0 (25.3, 26.7)	0.7 (−0.2, 1.5)	4.6 (4.0, 5.1)	0.2 (−0.5, 0.8)
Cycling						
Low	29.5 (29.3, 29.7)	Ref	24.9 (24.7, 25.2)	Ref	4.6 (4.4, 4.8)	Ref
Moderate	31.9 (31.3, 32.5)	2.4 (1.6, 3.1)	27.6 (27.0, 28.3)	2.7 (1.9, 3.5)	4.3 (3.7, 4.8)	−0.3 (−1.0, 0.3)
High	31.6 (30.7, 32.5)	2.1 (1.1, 3.0)	27.3 (26.4, 28.1)	2.4 (1.4, 3.3)	4.3 (3.5, 5.1)	−0.3 (−1.1, 0.6)
Domestic work						
Low	28.6 (28.2, 29.1)	Ref	24.4 (23.8, 25.0)	Ref	4.2 (3.8, 4.7)	Ref
Moderate	30.0 (29.4, 30.5)	1.4 (0.6, 2.1)	25.5 (24.7, 26.2)	1.1 (0.1, 2.1)	4.5 (3.9, 5.1)	0.3 (−0.5, 1.1)
High	31.2 (30.6, 31.8)	2.6 (1.9, 3.3)	26.8 (26.1, 27.5)	2.4 (1.5, 3.3)	4.5 (3.9, 5.0)	0.3 (−0.5, 0.9)
Sports						
Low	30.0 (29.7, 30.2)	Ref	25.5 (25.3, 25.8)	Ref	4.5 (4.3, 4.6)	Ref
Moderate	31.0 (30.3, 31.7)	1.0 (0.2, 1.8)	26.8 (26.1, 27.6)	1.3 (0.4, 2.1)	4.2 (3.6, 4.7)	−0.3 (−0.9, 0.4)
High	30.9 (30.0, 31.9)	0.9 (−0.1, 2.0)	26.6 (25.6, 27.6)	1.1 (0.0, 2.2)	4.3 (3.5, 5.2)	−0.2 (−1.1, 0.9)

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Table 3 Continued

	Total LE (years)	Dif Total LE (years)[b]	LE free of CVD (years)	Dif LE free of CVD (years)[b]	LE with CVD (years)	Dif LE with CVD (years)[b]
Gardening						
Low	30.0 (29.8, 30.2)	Ref	25.7 (25.4, 25.9)	Ref	4.3 (4.1, 4.5)	Ref
Moderate	31.1 (30.4, 31.9)	1.1 (0.3, 1.9)	26.6 (25.8, 27.4)	0.9 (0.0, 1.9)	4.6 (3.9, 5.3)	0.3 (−0.5, 1.0)
High	30.3 (29.2, 31.4)	0.3 (−0.9,1.5)	25.9 (24.7, 27.1)	0.2 (−1.1, 1.5)	4.4 (3.5, 5.4)	0.1 (−1.0, 1.1)

CVD, cardiovascular disease; LE, life expectancy; PA, physical activity; ref, referent.

[a]All life expectancies were calculated with sex-specific hazard ratios adjusted for age, smoking status, alcohol consumption in tertiles, education, marital status and cancer prevalence. For PA types, models were also adjusted for all other PA types. Unless otherwise indicated, data are reported as mean (95% CI) years.

[b]Differences are calculated using the low PA group as the reference: moderate versus low and high versus low.

attenuated the associations. Therefore, the results for Model 1 and 3 are presented in Supplementary Table 1. Sex-specific HRs used for the analyses are presented in Supplementary Table 2 and 3. High total PA was associated with a lower risk of incident CVD (HR: 0.73, 95% CI: 0.63, 0.85), compared to low PA, in Model 2. Regarding PA types, compared to the low category, the high level of cycling (HR: 0.77, 95% CI: 0.65, 0.91) and the medium category of sports (HR: 0.80, 95% CI: 0.68, 0.95) were associated with a lower risk of incident CVD.

Among participants without CVD, high total PA was associated with a lower mortality risk (HR: 0.66, 95% CI: 0.58, 0.75), compared to low PA. Regarding types, walking, cycling, domestic work, sports and gardening were each associated with 12–35% reduced mortality risk (Table 2). Compared to the low categories, the largest risk reductions were observed for the high categories of cycling, domestic work and gardening (Table 2).

Among participants with CVD, high total PA was associated with a lower mortality risk (HR: 0.73, 95% CI: 0.62, 0.86), compared to the low category. Regarding types, the medium category of walking (HR: 0.85, 95% CI: 0.73, 0.98) and sports (HR: 0.76, 95% CI: 0.63, 0.93) and the high category of cycling (HR: 0.76, 95% CI: 0.63, 0.93) were associated with reduced mortality risk, compared to the low categories.

The association between total PA and every PA type with the risk of each transition was translated into number of years lived with and without CVD (Table 3 and Fig. 1). Compared to men with low total PA, total LE was increased with 2.2 (95% CI: 1.5, 2.9) years in the medium category and 3.5 (95% CI: 2.8, 4.2) years in the high category. For women, these differences were 1.5 (95% CI: 0.8, 2.1) and 3.0 (95% CI: 2.3, 3.5) years, respectively (Table 3). The LE without CVD associated with total PA was up to 3.3 (95% CI: 2.5, 4.2) years in men and up to 2.8 (95% CI: 2.2, 3.6) years in women. In men, the amount of years lived with CVD was higher in the medium category of total PA.

Regarding types of PA, men and women in the medium and high category of walking, cycling, domestic work, sports and gardening had higher total LE and LE without CVD than participants in the low categories of these PA types, although the magnitude of the effect differed per PA type (Table 3).

In men and women, high cycling increased LE with 3.7 (95% CI: 3.0, 4.4) years and 2.1 (95% CI: 1.1, 3.0) years, respectively. In women, domestic work was also associated with large gains in LE, with up to 2.6 (95% CI: 1.9, 3.3) years for the high category. In men, both sports and gardening were associated with higher LE. The medium category of sports increased LE with 3.1 (95% CI: 2.3, 4.0) years, and the high category of gardening had 2.7 (95% CI: 1.9, 3.5) years higher LE, compared to the low category.

The largest gains in LE without CVD were found for cycling, with up to 3.3 (95% CI: 2.5, 4.2) years in men and 2.7 (95% CI: 1.9, 3.5) years in women. In men, the medium category of sports also increased LE without CVD with 2.9 (95% CI: 1.8, 4.0) years and the medium and high category of gardening increased LE with 2.4 (95% CI: 1.5, 3.4) and 2.0 (95% CI: 0.8, 3.1) years, respectively. In women, domestic work was associated with increases in LE in the medium and high category of 1.1 (95% CI: 0.1, 2.0) and 2.4 (95% CI: 1.5, 3.3) years, respectively.

Total LE and the number of years lived with and without CVD for participants without hypertension, diabetes and dyslipidemia are presented in Supplementary Figure 2 for total PA.

Compared to the population included in the main analyses, total LE was up to 1.2 year higher for individuals without hypertension, diabetes and dyslipidemia. Moreover, in

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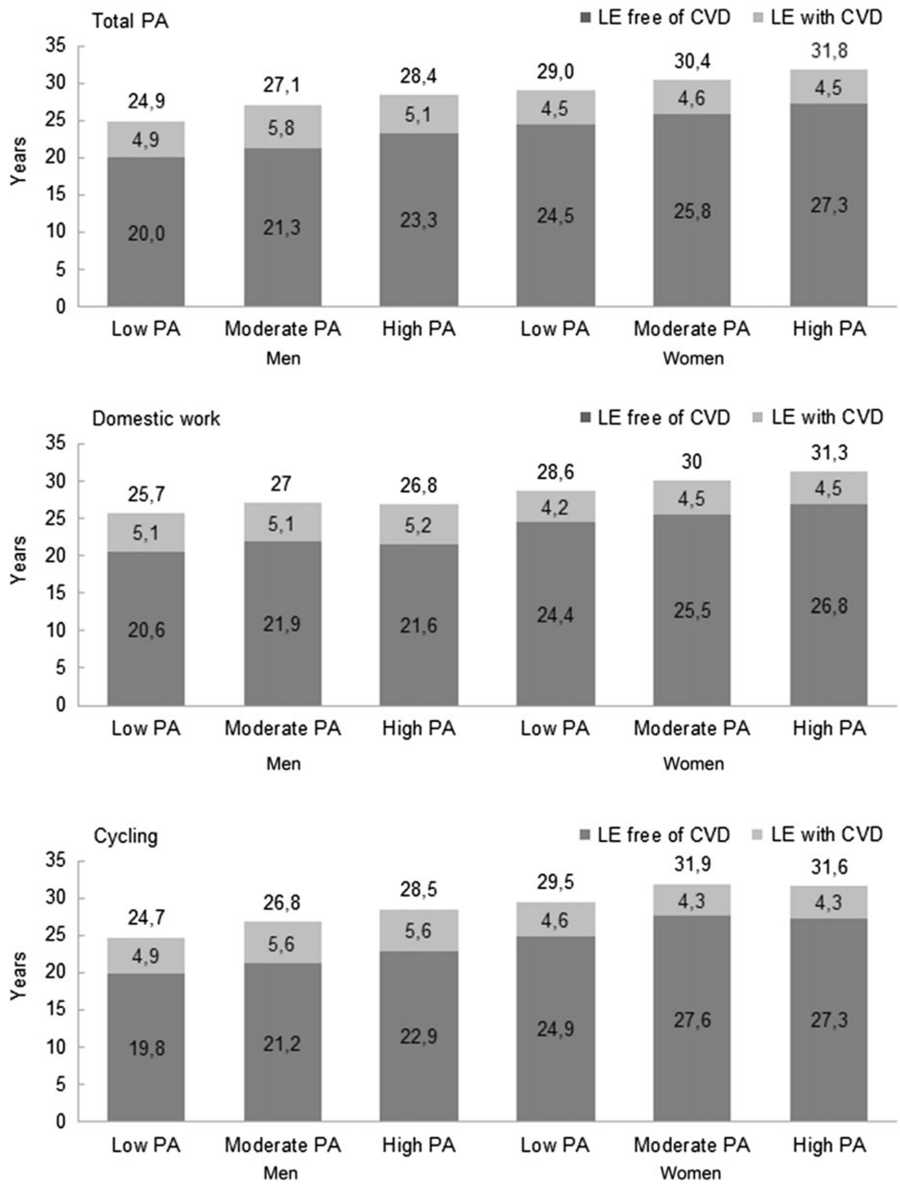

Fig. 1. Effect of physical activity on life expectancy with and without CVD at age 55 years. All life expectancies have been calculated with sex-specific hazard ratios adjusted for age, smoking status, alcohol consumption in tertiles, education, marital status and cancer prevalence. Models with PA types were additionally adjusted for the other PA types. Abbreviations: CVD, cardiovascular disease; LE, life expectancy; PA, physical activity.

this population, LE free from CVD was up to 1.6 year higher, whereas LE with CVD was lower.

Discussion

Main finding of this study

In this prospective cohort study, we found that high total PA at age 55 and over was associated with an increase in total LE and with a greater number of years lived without CVD. Cycling was associated with gains in total LE in both men and women. Additionally, domestic work in women and sports and gardening in men were independently associated with large increases in total LE. Cycling also had a beneficial effect on extending LE without CVD in both men and women. Total PA and types of PA had a small impact on years lived with CVD.

The higher LE free from CVD in individuals with higher PA levels was the result of a lower risk of CVD and mortality. Due to the lower CVD risk, the first CVD event occurs later in the lifespan and consequently, LE without CVD is increased. Furthermore, being free from CVD reduces the mortality risk and therefore increases the number of years

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lived and consequently the number of years free of CVD. We also found that men with higher levels of total PA, sports and cycling spent slightly more years with CVD, compared to men with low PA. The years lived with CVD are a consequence of the CVD risk in individuals without history of CVD, influencing the age of the first event, and mortality risk in those with CVD, determining the years lived after the CVD event. In our study, men with high PA and a history of CVD had a lower mortality risk and therefore they lived slightly longer with CVD.

What is already known on this topic

The HRs we found in our study support existing evidence that PA reduces the incidence of CVD.[3,24] Moreover, the reduction in mortality risk among persons without history of CVD associated with total PA, is in line with previous studies.[25,26] Our results also confirm that total PA reduces mortality in persons with a history of CVD.[25,27,28] The effects of specific types of PA, however, are less well-documented in literature. We found one study reporting the association between gardening, sports, walking and cycling with incident CVD, which reported similar HRs as we found.[29] Additionally, a study within the Whitehall population reported similar HRs for all-cause mortality for cycling, sports and gardening.[30] In this study, domestic work did not reduce mortality risk, which might be related to the slightly younger participants (mean age 56 years).

What this study adds

Our study is the first to report mortality risk for several PA types among participants with and without prevalent CVD. Moreover, we revealed that cycling, sports and walking not only prevented the first cardiovascular event in those without CVD, but also improved the prognosis of CVD in participants with CVD. In our study, compared to low PA, we found increases in LE for high PA which are similar to findings from other studies.[6–10] One study found a slightly higher LE,[7] which could be explained by the fact that they only looked at leisure time PA, whereas we evaluated leisure time, housework and transportation combined. Additionally, compared to low PA, we found increases in LE without CVD for high total PA of 3.3 in men and 2.8 in women, comparable to previous studies.[9,10] In earlier studies comprising participants from the Framingham Heart Study, at age 50, high PA was associated with increases in LE without CVD of 3.0–3.2 years for men and 3.1–3.3 years for women, compared to low PA.[9,10] This study included participants aged 50 years, between 1948 and 1950, and followed them up until the end of the 20th century, whereas we included participants starting from 1999 and followed them until 2010. After 1990, the treatment for cardiovascular risk factors has improved, which resulted in the reduction of cardiovascular incidence and mortality rates.[11] Additionally, it might be expected that our population was less physically active, due to population changes in PA over the years. In spite of these population differences, the relative contribution of high PA compared to low PA has remained stable, indicating that being physically active can protect against CVD, independent of differences in the population.

In our analyses, cycling was an important contributor to the effect of total PA. Furthermore, domestic work was important for women, whereas gardening and sports were important for men. The beneficial effect of several different PA types on LE has not been studied before and we are the first to show that these PA types have independent effects on total LE and LE without CVD. However, previous studies have shown beneficial effects of cycling, domestic work and sports on CVD and mortality risk.[29,31–35] Moreover, whereas the World Health Organization recommends to engage in 30 minutes of PA, 5 days a week, to gain health benefits,[36] our results suggest that 13 minutes of cycling per day (the medium category) can already increase LE with 2.1 years in men and 2.4 years in women. This has also been shown in another study,[37] in which an increase in total LE of 3 years was reported for 15 minutes of leisure time PA per day. Regarding other specific PA types, we only found one study reporting on walking, with increases in LE similar to ours.[38]

Limitations of this study

This study has some limitations. First, we did not collect information on occupational PA, so we could not adjust for this in our analyses. However, since only 11.5% was employed at baseline, we do not believe this would have significantly influenced our results. Second, although our questionnaire has been validated,[15] some error in self-report is inevitable. Moreover, since PA was measured at baseline only, this could have led to misclassification of PA over time. These last two limitations could have resulted in bias towards the null. Furthermore, people in poor health might participate in PA less than others, creating the opportunity for reverse causation. However, we adjusted for diabetes and hypertension in our third model and observed no major changes in the HRs. Finally, we excluded individuals that did not complete PA data collection. These individuals were slightly older and more often female.

Major strengths of the current study are our relatively long follow-up period in a well-defined prospective population-based cohort study. Furthermore, we had a very

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accurate method of outcome ascertainment and we were able to adjust for several factors, thereby minimizing the possibility of the observed associations being explained by confounding. Additionally, by including a number of different physical activities, while adjusting for the remaining activities, we could examine their independent associations with CVD and mortality.

Conclusions

We conclude that high levels of PA are associated with a higher LE and prolonged years lived without CVD. Cycling contributed most to the most health benefits in both men and women, whereas domestic work contributed in women and sports and gardening contributed in men. Such activities could be more strongly encouraged in activity guidelines to maximize the population benefits of PA.

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Supplementary data

Supplementary data are available at the *Journal of Public Health* online.

Conflict of interest

None.

Authors' contributions

The contribution of the authors were as follows: KD, CK and OHF had the original idea for the study. KD and CK 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. OHF, KD supervised analyses of study data. OHF, AP, FBH, MB, WN, AH, MAI and HT revised the manuscript critically for important intellectual content and gave final approval of the version to be published.

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