Effect of intensity and type of physical activity on mortality: results from the Whitehall II cohort study.

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Objectives. We examined the association of intensity and type of physical activity with mortality.

Methods. We assessed the duration of physical activity by intensity level and type in 7456 men and women from the Whitehall II Study by questionnaire in 1997–1999 (mean ±SD age=55.9 ±6.0 years) and 5 years later. All-cause mortality was assessed until April 2009.

Results. A total of 317 participants died during the mean follow-up of 9.6 years (SD=2.7). Reporting at least 1 hour per week of moderate activity was associated with a 33% (95% confidence interval [CI]=14%, 45%) lower risk of mortality compared with less than 1 hour. For all physical activity types examined, except housework, a duration of physical activity greater than 0 (≥3.5 hours for walking) was associated with lower mortality in age-adjusted analyses, but only the associations with sports (hazard ratio [HR]=0.71; 95% CI=0.56, 0.91) and do-it-yourself activity (HR=0.68; 95% CI=0.53, 0.98) remained in fully adjusted analyses.

Conclusions. It is important to consider both intensity and type of physical activity when examining associations with mortality. (*Am J Public Health.* 2012; 102:698–704. doi:10.2105/AJPH.2011.300257)

The dose-response association between physical activity and all-cause mortality is well established,[1,2] but few studies have investigated whether the different types of leisure-time physical activity are equally beneficial.[3–5] There are a variety of ways to expend energy, such as sports, walking, and domestic physical activity, and different types of activities require different levels of energy expenditure.[6] Sports activities have been clearly shown to be associated with a lower risk of mortality.[3,5,7,8] However, less is known about less intensive physical activities, particularly those that are a part of daily living and leisure. Two recent reports showed "global domestic activity" to protect against all-cause mortality,[3,5] and a previous article on Finnish data suggested that specific types of domestic physical activity may have a protective effect.[4] Our objective in the present study was to examine the associations of mortality with intensity, in terms of mild, moderate, and vigorous activity, and type of physical activity, specifically, walking, sports, housework, gardening, and do-it-yourself activities.

METHODS

Data were drawn from the Whitehall II Study, which was established in 1985 as a longitudinal study on 10 308 civil servants (6895 men and 3413 women).[9] All civil servants aged 35 to 55 years in 20 London-based departments were invited to participate by letter, and 73% agreed. The baseline examination (phase 1) took place from 1985 to 1988 and involved a clinical examination and a self-administered questionnaire that included sections on lifestyle factors. Subsequent phases of data collection alternated between postal questionnaire alone (phases 2 [1988–1990], 4 [1995–1996], 6 [2001], and 8 [2006]) and postal questionnaire accompanied by a clinical examination (phases 3 [1991–1993], 5 [1997–1999], and 7 [2002–2004]). The participants gave written consent to participate in the study, and the University College London ethics committee approved the study.

Detailed measures of physical activity were introduced to the study at phase 5 and were repeated at phase 7. Hence, the study population for the present analysis was composed of 7456 participants with complete data on physical activity measures and all covariates at phase 5 (mean ±SD age=55.9 ±6.0 years; range=44.8–69.1) or at phase 7 (mean ±SD age=61.2 ±6.0 years; range=50.5–74.1).

Physical Activity

The questionnaire on physical activity assessed both leisure-time and job-related activities, using the following instructions: "We would like to know about your activities at work and in your free time that involve physical activity." The questionnaire included 20 items on the amount of time spent in the following activities: walking, sports (cycling, soccer, golf, swimming, and 2 open-ended questions on other sports), gardening (weeding, mowing, and 1 open-ended question on other gardening activities), housework (carrying heavy shopping, cooking, hanging out washing, and 2 open-ended questions on other housework), do-it-yourself activity (a term used to describe building, modifying, or repairing something without the aid of experts or professionals, such as manual car washing, painting, or decorating, and 1 open-ended question on other do-it-yourself activity), and 2 open-ended questions on other activities. This is a modified version of the previously validated Minnesota leisure-time physical activity questionnaire.[10] For each item, the participants were required to provide the total number of hours spent in that activity over the past 4 weeks to give an indication of usual activity.

Subsequently, for each activity including the open-ended items we assigned a metabolic equivalent (MET) value by using a compendium of activity energy costs.[11] One MET value reflects the intensity of the activity relative to lying quietly. We classified the intensity of physical activity by using the MET value and recoded it as mild physical activity for values less than 3 (e.g., dish washing, boating), moderate physical activity for values ranging from 3 to 5.9

(e.g., cycling, weeding), and vigorous physical activity for values of 6 or greater (e.g., swimming, mowing).[12] Because no information was collected on the pace of walking at phase 5, we set an a priori MET value of 2.9 for walking at both phases 5 and 7. We calculated the total number of hours per week spent in mild, moderate, and vigorous physical activity; in addition, we also calculated the total number of hours per week spent in each type of physical activity: walking, sports, gardening, housework, and do-it-yourself. At phase 7, a question on usual walking pace was added to the study; this measure was categorized as slow pace, steady average pace, and brisk or fast pace.

Mortality

A total of 10 297 respondents (99.9%) were successfully traced for mortality through the national mortality register kept by the National Health Services Central Registry by using the National Health Service identification number assigned to each British citizen. In our analysis, mortality follow-up began at the date at which the participant had data on physical activity and the covariates (phase 5 or 7) and ended on April 30, 2009.

Covariates

The sociodemographic variables used were age, gender, marital status (married or cohabiting, single, widowed, and divorced or separated), and socioeconomic status (6-level civil service employment grade) at phases 5 and 7. Employment grade in the Whitehall II Study is a comprehensive marker of socioeconomic circumstances and is related to salary, social status, and level of responsibility.[9]

Health behaviors were drawn from phases 5 and 7 and were assessed by using smoking status, alcohol consumption, and frequency of fruit and vegetable consumption. Smoking was assessed by questions on current smoking status (current, past, or never smoker). Alcohol consumption was assessed by questions on the number of alcoholic drinks ("measures" of spirits, "glasses" of wine, and "pints" of beer) consumed in the past 7 days. This was converted to number of units (1 unit=8 g) of alcohol. The frequency of fruit and vegetable consumption was assessed on an 8-point scale, ranging from "seldom or never" to "2 or more times a day."

Health measures were drawn from phases 5 and 7. Coronary heart disease prevalence was based on clinically verified events and included myocardial infarction and definite angina.[13] Stroke was assessed by using a self-reported measure of physician diagnosis. Diabetes assessment was based on self-reports and glucose tolerance test by using the World Health Organization criteria. Self-rated health was assessed by the following question, "In general, would you say your health is: excellent, very good, good, fair, or poor?"

Statistical Analysis

The nature and number of hours (duration) of physical activity reported were used to operationalize both the intensity (mild, moderate, and vigorous) and type (walking, sports, gardening, housework, and do-it-yourself) of physical activity. The duration measure was categorized into tertiles except for activities not practiced by more than 40% of the population (vigorous activity, sports, gardening, and do-it-yourself), for which the bottom category for duration was no participation and the remaining 2 categories were divided by using the median value.

Given the importance of taking into account changes in physical activity over time,[14,15] we used data on physical activity from phases 5 and 7 (N=7456) to constitute 3 participant groups. For the biggest group, composed of those who responded at both phases (n=5549), data on physical activity at phase 5 were used for their contribution to the calculation of person-years until phase 7, and then data at phase 7 were used until either death or the end of follow-up on April 30, 2009. The second group, composed of responders to only phase 5 (n=975), contributed to person-years until death or phase 7, whichever came first. The last group, composed of responders to phase 7 but not phase 5 (n=932), contributed to person-years until either their date of death or the end of follow-up.

For the categories of physical activity type and intensity defined by duration, we calculated the mortality rates per 1000 person-years standardized for age (5-year age groups) with the direct method by using the whole analytic sample as the standard population. Subsequently, we used Cox regression with delayed entry and age as timescale to estimate hazard ratios (HRs) and their 95% confidence intervals (CIs) for the association between physical activity and all-cause mortality. Physical activity measures and covariates were entered as time-dependent variables in the model to take into account changes over time. The proportional hazards assumption for the Cox model was confirmed formally by the Shoenfeld's test. Tests for linear trend across the categories of duration of physical activity were obtained by entering the categorical variables as a continuous parameter in the Cox model. Restricted cubic spline regressions with Harrell knots[16] were also used to check for the shape of the association of duration between physical activity and mortality.

The associations between physical activity and mortality were examined in 4 serially adjusted models. Model 1 was the unadjusted model using age as the timescale. Model 2 was the mutually adjusted model, in which the other measures of intensity (or type) of physical activity were simultaneously entered in the regression to evaluate their independent effects on mortality. Model 3 additionally adjusted for sociodemographic variables (gender, marital status, and socioeconomic status). Finally, model 4 included other health behaviors (smoking, alcohol consumption, and fruit and vegetable consumption) and health measures (coronary heart disease, stroke, diabetes, and self-rated health).

Additional analysis was undertaken on the study population who responded to the question on walking pace at phase 7 (n=6323). The association between self-reported walking pace and mortality was examined by using the methods described above. All analyses were performed with SAS version 9.2 (SAS Institute Inc, Cary, NC).

RESULTS

A total of 7456 participants were included in the analyses, and 317 died during the follow-up, a mean period of 9.6 years (SD=2.7). Compared with those not included in the analysis, this group was younger (55.8 vs 56.4 years, $P<.001$), was composed of fewer women (30.1% vs 41.1%, $P<.001$), and had fewer participants from the lower socioeconomic group (17.3% vs 36.9%, $P<.001$).

The characteristics of the study participants included in the analysis as a function of the

total number of hours of physical activity per week are presented in Table 1. Participants doing more than 12 hours of physical activity per week were more likely to be older, to be female, to be from the higher socioeconomic group, to not be married or cohabiting, to drink more alcohol, and to eat fruit and vegetables more frequently and were less likely to be diabetic and report fair or poor health (all $P<.05$). There was no evidence that the association of the physical activity intensity levels and types with mortality differed by gender (all P for interaction$>.18$) or age (all P for interaction$>.1$), leading us to combine men and women and all age groups in the analysis.

The self-reported duration of each type of physical activity at the 3 intensity levels (mild, moderate, vigorous) and vice versa is shown in Table 2. In this middle-aged cohort, all activity types except housework and walking were mainly practiced at the moderate intensity level. The correlation between hours of mild and moderate physical activity was 0.10, that between mild and vigorous activity was 0.03, and that between moderate and vigorous activity was 0.24 (all $P<.001$). Housework was inversely correlated with sports (–0.06) and do-it-yourself activities (–0.08), whereas all other types of activity were positively correlated with each other (correlations ranging from 0.05 to 0.26; all $P<.001$).

Association Between Self-Reported Physical Activity Intensity and Mortality

The association between intensity of self-reported physical activity and mortality is presented in Table 3. In the age-adjusted model (model 1), compared with those in the lowest category of physical activity both the intermediate and the top groups showed a lower risk of mortality. Comparing the top with the bottom group, this was true for moderate (HR=0.48; 95% CI=0.37, 0.63) and vigorous (HR=0.62; 95% CI=0.45, 0.86) activities, although in the mutually adjusted analysis (model 2), only moderate levels of activity remained associated with mortality (HR=0.54; 95% CI=0.41, 0.72). In analyses adjusted for all covariates (model 4), those reporting at least 1 hour of moderate activity had a 33% (95% CI=14%, 45%) lower risk of death than did those whose duration of moderate-level activity was less than 1 hour. The test for trend associated with hours of moderate physical activity, $P=.006$, suggested a dose-response association. However, further analysis using spline regression, where the P for nonlinearity was $<.001$, suggested that the linear trend effect was being driven by the difference between the bottom group and the top 2 groups rather than by a dose-response association.

Association Between Self-Reported Physical Activity Type and Mortality

The association between self-reported physical activity type and mortality is presented in Table 4. In the age-adjusted models, all physical activity types except housework were associated with lower mortality. When all physical activity types were entered simultaneously in the model (model 2), these associations were somewhat reduced (HRs for the top vs the bottom group were 0.72 [95% CI=0.55, 0.95] for walking, 0.62 [95% CI=0.46, 0.83] for sports, 0.75 [95% CI=0.56, 1.00] for gardening, and 0.66 [95% CI=0.49, 0.90] for do-it-yourself activity). In the fully adjusted model (model 4), only the associations with sports and do-it-yourself activity remained, whereas those with walking and gardening were substantially reduced. Although the test for trend for sports and do-it-yourself activity had P values lower than 0.05, there was no clear dose-response association. In fact, the mortality risk reduction, at around 30%, was evident for those reporting any amount of these activities (compared with none) with no additional benefit for longer duration. Indeed, spline regressions showed no evidence of linearity for sports (P for nonlinearity$<.001$), gardening (P for nonlinearity$=.002$), and do-it-yourself activity (P for nonlinearity$<.001$).

In additional analyses, we summed the reported hours of gardening, housework, and do-it-yourself activities to create a global "domestic physical activity" category. We repeated the analysis reported in Table 4 by using this measure; the age-adjusted analysis showed a lower risk of mortality among those reporting more than 6 hours of domestic physical activities compared with the less than 3 hours category (HR=0.73; 95% CI=0.56, 0.96). However, the HR was considerably attenuated

TABLE 1—Characteristics of the Population as a Function of Total Physical Activity: Whitehall II Study, London, UK, 1997–1999 and 2002–2004

	Total Physical Activity, H/Wk, No.			
	≤8	8.1–12	>12	P^a
No. (%)	2415 (32.4)	2361 (31.7)	2680 (35.9)	
Sociodemographic variables				
Age, mean (SD)	55.2 (5.9)	55.4 (5.9)	57.0 (6.1)	<.001
Women, no. (%)	624 (25.8)	715 (30.3)	904 (33.7)	<.001
Lower socioeconomic status, no. (%)	416 (17.2)	298 (12.6)	352 (13.1)	<.001
Married or cohabiting, no. (%)	1882 (77.9)	1799 (76.2)	1996 (74.5)	.02
Health behaviors				
Never smokers, no. (%)	261 (10.8)	266 (11.3)	291 (10.9)	.86
Units of alcohol consumption, mean (SD)	12.7 (15.2)	13.8 (15.5)	13.6 (15.5)	.02
Fruit and vegetables ≥2/d no. (%)	691 (28.6)	857 (36.3)	1180 (44.0)	<.001
Health				
Coronary heart disease, no. (%)	168 (7.0)	139 (5.9)	162 (6.0)	.25
Stroke, no. (%)	23 (1.0)	22 (0.9)	18 (0.7)	.47
Diabetes, no. (%)	181 (7.5)	129 (5.5)	153 (5.7)	.006
Self-rated fair or poor health, no. (%)	507 (46.9)	304 (28.2)	269 (24.9)	<.001
Deaths, no. (%)	105 (4.4)	100 (4.2)	112 (4.2)	.96

Note. Measured at the date of entry in the survey analysis (phase 5 for those with complete data at phase 5 [N=6524]; phase 7 for those with missing data at phase 5 but not at phase 7[N=932]).
[a]P for heterogeneity.

TABLE 2—Duration of Physical Activity as a Function of Type and Intensity of Physical Activity: Whitehall II Study, London, UK, 1997–1999 and 2002–2004

	Hours/Week, Mean (SD)
Type of Physical Activity	
Walking (n = 7042): mild level	4.99 (2.72)
Sports (n = 3410)	
Mild level	0.03 (0.31)
Moderate level	1.70 (1.83)
Vigorous level	0.53 (0.86)
Gardening (n = 5073)	
Mild level	0.00 (0.04)
Moderate level	1.40 (1.42)
Vigorous level	0.34 (0.57)
Housework (n = 6983)	
Mild level	2.92 (2.38)
Moderate level	0.10 (0.45)
Vigorous level	0.00 (0.05)
Do-it-yourself activity (n = 4129)	
Mild level	0.01 (0.11)
Moderate level	1.44 (1.43)
Vigorous level	0.07 (0.07)
Intensity of Physical Activity	
Mild (n = 7409)	
Walking	4.75 (2.87)
Sports	0.02 (0.21)
Gardening	0.00 (0.03)
Housework	2.76 (2.41)
Do-it-yourself activity	0.00 (0.08)
Moderate (n = 6245):	
Sports	0.93 (1.59)
Gardening	1.14 (1.39)
Housework	0.11 (0.47)
Do-it-yourself activity	0.95 (1.35)
Vigorous (n = 3649)	
Sports	0.53 (0.88)
Gardening	0.48 (0.63)
Housework	0.00 (0.07)
Do-it-yourself activity	0.08 (0.42)

Note. MET = metabolic equivalent. Mild level was defined as < 3 MET, moderate level as 3–5.9 MET, and vigorous level as ≥ 6 MET. Sample sizes were calculated on the basis of those practicing the activities.

in the fully adjusted analysis; the HR in model 4 was 0.87 (95% CI=0.65, 1.15).

The analysis on self-reported walking pace and mortality, based on 6323 participants from phase 7 with 189 deaths until the end of follow-up on April 30, 2009, showed higher walking pace to be associated with a lower risk of mortality in the fully adjusted analysis (compared with slow pace, HR=0.76; 95% CI=0.52, 1.09 for steady average pace and HR=0.60; 95% CI=0.37, 0.96 for brisk or fast pace; *P* for trend=.03). For comparison, we examined the duration of walking in the same sample and found it to not be associated with mortality in a fully adjusted analysis (for those walking >6 hours/ week compared with those walking <3.5 hours: HR=0.76; 95% CI=0.54, 1.08).

Because the participants were asked to report the physical activity undertaken in the previous 4 weeks, we examined whether the season during which the questionnaire was completed influenced the results. We constructed an indicator showing whether the participants had responded during the colder months, from November to April. The mortality rate in these 2 groups was not significantly different; 4.34 deaths per 1000 person-years for those responding in the colder months compared with 4.55 for others (HR=0.95; 95% CI=0.76, 1.19; *P*=.68). The interaction terms between seasonality and physical activity variables (all *P*>.2) on mortality showed that the former did not influence the results reported here.

DISCUSSION

Data from the Whitehall II prospective cohort study showed that those who reported undertaking little or no physical activity, classified by intensity level or type of activity, had a higher risk of death in late midlife. Our study presented 4 key findings. First, participants reporting at least 1 hour of physical activity at moderate intensity levels had a one third lower risk of mortality, independently of physical activity at other intensity levels and multiple covariates. Second, among the different types of physical activity examined—walking, sports, gardening, housework, and do-it-yourself activity—all except housework were associated with lower mortality, but these associations were robust to adjustment for covariates only for sports and do-it-yourself activities. Third, self-reported walking pace rather than its duration was associated with mortality. Finally, results using a global measure of "domestic physical activities" combining gardening, housework, and do-it-yourself activity should be interpreted with caution because they combine activities that have different intensity levels and different associations with mortality.

Comparison With Previous Studies

Although the relation between physical activity and mortality is robust,[1,2] it has mostly been examined by using an index of total energy expenditure[1,4,8,17–19] or a priori categories to define light, moderate, and heavy physical activity that then conflate information on duration from these different intensity levels of physical activity.[1,15,20,21] Few studies have investigated the independent effects of the various levels of physical activity.[1,6] One study found moderately vigorous (MET ≥ 4.5) but not lower energetic activities to be associated with reduced risk of mortality[22]; others compared vigorous and nonvigorous activities and showed that only vigorous activities were associated with reduced risk of mortality.[19,23] However, in all these studies nonvigorous activity combined mild and moderate activities, thus leading to some dilution of the effect of moderate activity. One study examined the independent effect of mild, moderate, and vigorous activities and concluded that only vigorous activities are beneficial.[24] But that study did not take into account health measures, a possible confounder in the association between physical activity and mortality. Our results suggest that moderate physical activity in late midlife is independently associated with a reduced risk of mortality. The results for vigorous activity were not robust to adjustment for health measures, thus possibly being affected by reverse causation (i.e., poor health precludes vigorous exercise). Two previous reviews also noted the leveling off in the impact of intensity of physical activity,[1,2] although it must be noted that our analyses were underpowered because of the small number of participants undertaking vigorous physical activity.

In addition to the intensity of physical activity, there is increasing literature on the impact of type of activity undertaken. Studies that have examined the association between leisure-time physical activity and mortality show mixed results.[4,7,15,25–27] It is possible that the inconsistency in results stems from the heterogeneity in the types of activities covered

TABLE 3—Association Between Self-Reported Duration of Physical Activity at Different Intensity Levels and Mortality: Whitehall II Study, London, UK, 1997-2009

Intensity of Physical Activity	Person-Years	No. of Deaths	Rate/1000 Person-Years[a]	Model 1, HR (95% CI)	Model 2, HR (95% CI)	Model 3, HR (95% CI)	Model 4, HR (95% CI)
Mild activities							
<5.5 h/wk	23 603	120	5.25	1	1	1	1
5.5–8.9 h/wk	24 218	93	3.96	0.75* (0.57, 0.98)	0.79 (0.60, 1.04)	0.78 (0.59, 1.02)	0.85 (0.64, 1.12)
≥9.0 h/wk	23 787	104	4.14	0.78 (0.60, 1.02)	0.83 (0.64, 1.09)	0.82 (0.63, 1.08)	0.93 (0.71, 1.23)
P for trend				.07	.219	.17	.64
Moderate activities							
<1.0 h/wk	22 999	139	6.67	1	1	1	1
1.0–3.4 h/wk	23 881	88	3.79	0.57* (0.43, 0.74)	0.61* (0.46, 0.79)	0.61* (0.46, 0.80)	0.67* (0.51, 0.88)
≥3.5 h/wk	24 728	90	3.29	0.48* (0.37, 0.63)	0.54* (0.41, 0.72)	0.55* (0.41, 0.73)	0.67* (0.50, 0.91)
P for trend				<.001	<.001	<.001	.006
Vigorous activities							
None	37 697	202	5.38	1	1	1	1
0.1–0.9 h/wk	20 883	72	3.48	0.65* (0.50, 0.86)	0.73* (0.55, 0.96)	0.72* (0.55, 0.95)	0.82 (0.62, 1.08)
≥1.0 h/wk	13 028	43	3.21	0.62* (0.45, 0.86)	0.74 (0.52, 1.03)	0.74 (0.53, 1.05)	0.90 (0.64, 1.28)
P for trend				<.001	.02	.02	.32

Note. CI = confidence interval; HR = hazard ratio. Model 1 was adjusted for age. Model 2 was adjusted for the variables in model 1 and mutually adjusted for all physical activity intensity levels. Model 3 was adjusted for the variables in model 2 plus sociodemographic variables (gender, socioeconomic status, and marital status). Model 4 was adjusted for model 3 plus other health behaviors (smoking, alcohol consumption, and fruit and vegetable consumption) and health (diabetes, coronary heart disease, stroke, and self-rated health).
[a]Rate was adjusted for age.
*$P < .05$.

by the term leisure-time physical activity. Sport as a physical activity has consistently been found to be associated with a lower risk of mortality.[3,5,7,8] Results on walking are inconsistent with some studies finding an association with reduced mortality[18,24,28] and others not.[3,5,8] A recent meta-analysis concluded that self-reported walking pace rather than time spent walking might be associated with survival.[29] Indeed, this hypothesis was supported in our analysis and in the few other studies that have examined this association.[30,31]

In the present study, the sum of all domestic activities was found to not be associated with mortality. This might be because the combination of mildly energetic activities (e.g., housework) and more energetic activities (e.g., do-it-yourself) dilutes the effect. Similarly, differences in the effects of hours spent walking and walking pace show the importance of the intensity of the physical activity in question.

Research interest in the benefits of domestic physical activity has increased with some recent studies showing it to be associated with a lower risk of mortality.[3,5] In one study,[5] heavy domestic activities were assessed during interviews with a question on the frequency of "heavy housework/gardening/do-it-yourself" activities with examples presented on a card. In another study,[3] 6 activities in and around the home were collected by questionnaire; mowing the lawn, digging, and stair climbing were retained as heavy domestic activities. Neither study made a distinction in the type of activity undertaken, but a Finnish study that made this distinction found leisure-time forestry work, gardening, and engine repair to be associated with reduced risk of mortality.[4] Our results show that do-it-yourself activities are associated with a 30% lower risk of mortality, but that the association with gardening is substantially explained by health measures, and that there is no association with housework. It is possible that our results on gardening differ from those of the Finnish study[4] because, as has been suggested previously, gardening in rural Finland compared with England is likely to be more intensive in terms of energy expended.[5]

Strengths and Limitations

The primary strength of this study was the detailed assessment of physical activity by use of a 20-item questionnaire on several activities with open-ended questions for completeness. Intensity levels were based on MET values rather than self-report of energy expenditure. Analysis that took into account changes over time in physical activity and potential confounders was a further strength, because it has been shown that the use of a single assessment of physical activity at baseline underestimates its association with mortality.[14] The fact that the physical activity questionnaire was adapted to assess leisure-time and job-related physical activity may provide a more complete assessment.

The limitations of this study must also be noted. First, the physical activity assessment was based on self-reports, assessing levels of activity over the 4 previous weeks. This was a potential source of bias because of issues of seasonality. However, our analysis showed that the season during which the questionnaire was completed did not unduly affect the results. Second, because the number of deaths was small we were not able to explore associations with cause-specific mortality. Third, the study population, composed of white-collar civil

TABLE 4—Association Between Self-Reported Duration of Physical Activity of Different Types and Mortality: Whitehall II Study, London, UK, 1997-2009

Type of Physical Activity	Persons-Years	No. of Deaths	Rate per 1000 Person-Years[a]	Model 1, HR (95% CI)	Model 2, HR (95% CI)	Model 3, HR (95% CI)	Model 4, HR (95% CI)
Walking							
<3.5 h/wk	24 240	132	5.46	1	1	1	1
3.5–5.9 h/wk	24 364	95	4.13	0.75* (0.57, 0.97)	0.79 (0.60, 1.03)	0.77 (0.59, 1.00)	0.83 (0.63, 1.08)
≥6.0 h/wk	23 004	90	3.70	0.67* (0.51, 0.88)	0.72* (0.55, 0.95)	0.70* (0.54, 0.92)	0.81 (0.61, 1.07)
P for trend				.003	.02	.01	.14
Sports							
None	37 509	215	5.65	1	1	1	1
0.1–1.9 h/wk	15 534	42	2.97	0.54* (0.39, 0.76)	0.57* (0.41, 0.80)	0.58* (0.41, 0.80)	0.67* (0.48, 0.94)
≥2.0 h/wk	18 565	60	3.10	0.55* (0.41, 0.73)	0.62* (0.46, 0.83)	0.61* (0.46, 0.82)	0.73* (0.55, 0.99)
P for trend				<.001	<.001	<.001	.02
Gardening							
None	21 883	124	6.18	1	1	1	1
0.1–1.4 h/wk	27 811	103	3.89	0.64* (0.49, 0.82)	0.73* (0.56, 0.96)	0.75* (0.57, 0.98)	0.82 (0.62, 1.07)
≥1.5 h/wk	21 913	90	3.59	0.58* (0.44, 0.76)	0.75* (0.56, 1.00)	0.75 (0.56, 1.01)	0.88 (0.66, 1.20)
P for trend				<.001	.03	.04	.36
Housework							
<1.5 h/wk	26 086	105	4.32	1	1	1	1
1.5–3.9 h/wk	23 295	102	4.42	1.03 (0.78, 1.35)	0.99 (0.76, 1.31)	1.02 (0.77, 1.35)	1.02 (0.77, 1.35)
≥4.0 h/wk	22 227	110	4.65	1.07 (0.82, 1.40)	0.98 (0.74, 1.28)	1.11 (0.82, 1.50)	1.08 (0.80, 1.47)
P for trend				.63	.99	.44	.53
Do-it-yourself							
None	31 281	181	5.89	1	1	1	1
0.1–0.9 h/wk	20 913	73	3.43	0.59* (0.45, 0.77)	0.68* (0.51, 0.91)	0.63* (0.47, 0.84)	0.69* (0.51, 0.92)
≥1.0 h/wk	19 414	63	3.19	0.55* (0.42, 0.74)	0.66* (0.49, 0.90)	0.60* (0.44, 0.83)	0.67* (0.48, 0.92)
P for trend				<.001	.003	.001	.008

Note. CI = confidence interval; HR = hazard ratio. Model 1 was adjusted for age. Model 2 was adjusted for the variables in model 1 and mutually adjusted for all types of physical activity. Model 3 was adjusted for the variables in model 2 plus sociodemographic variables (gender, socioeconomic status, and marital status). Model 4 was adjusted for model 3 plus other health behaviors (smoking, alcohol consumption, and fruit and vegetable consumption) and health (diabetes, coronary heart disease, stroke, and self-rated health).
[a]Rate was adjusted for age.
*P < .05.

servants, is unlikely to be representative of the general population. Although the sample covered a wide socioeconomic range, with annual full-time salaries ranging from £4995 to £150 000, no unemployed or blue-collar workers were included. The fact that two thirds of the sample was composed of men also limits its generalizability. The mortality rate was smaller in the population study (4.2%) than it was in the entire cohort (6.6%), which suggests that the results were based on a healthier subsample of the study. Finally, in larger sample sizes finer categorizations, particularly for vigorous physical activities, might reveal additional benefits for health.

Our results show the importance of intensity of physical activity in terms of mortality outcomes. In this middle-aged cohort, moderate self-reported physical activity was associated with a reduced risk of mortality independently of mild and vigorous activities. Furthermore, our results suggest that the type of leisure-time physical activities matters, with beneficial effects evident only when activity is performed at a sufficiently intense level. In our study, sports and do-it-yourself activities were found to be protective against mortality. Higher walking pace but not duration of walking was associated with lower risk of mortality. The results of our study show the importance of considering both the intensity level and the type of activity when examining the impact of physical activity on mortality. ■

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S. Sabia and A. Dugravot analyzed the data. S. Sabia wrote the first full draft of the article. All authors jointly

designed the hypothesis, interpreted the data, and edited the article. S. Sabia is the guarantor for the article.

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Human Participant Protection

Participants gave written consent to participate in the study and the University College London ethics committee approved the study.

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