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Association of "Weekend Warrior" and Other Leisure Time Physical Activity Patterns With Risks for All-Cause, Cardiovascular Disease, and Cancer Mortality

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Invited Commentary

Supplemental content

IMPORTANCE More research is required to clarify the association between physical activity and health in "weekend warriors" who perform all their exercise in 1 or 2 sessions per week.

OBJECTIVE To investigate associations between the weekend warrior and other physical activity patterns and the risks for all-cause, cardiovascular disease (CVD), and cancer mortality.

DESIGN, SETTING, AND PARTICIPANTS This pooled analysis of household-based surveillance studies included 11 cohorts of respondents to the Health Survey for England and Scottish Health Survey with prospective linkage to mortality records. Respondents 40 years or older were included in the analysis. Data were collected from 1994 to 2012 and analyzed in 2016.

EXPOSURES Self-reported leisure time physical activity, with activity patterns defined as inactive (reporting no moderate- or vigorous-intensity activities), insufficiently active (reporting <150 min/wk in moderate-intensity and <75 min/wk in vigorous-intensity activities), weekend warrior (reporting ≥150 min/wk in moderate-intensity or ≥75 min/wk in vigorous-intensity activities from 1 or 2 sessions), and regularly active (reporting ≥150 min/wk in moderate-intensity or ≥75 min/wk in vigorous-intensity activities from ≥3 sessions). The insufficiently active participants were also characterized by physical activity frequency.

MAIN OUTCOMES AND MEASURES All-cause, CVD, and cancer mortality ascertained from death certificates.

RESULTS Among the 63 591 adult respondents (45.9% male; 44.1% female; mean [SD] age, 58.6 [11.9] years), 8802 deaths from all causes, 2780 deaths from CVD, and 2526 from cancer occurred during 561 159 person-years of follow-up. Compared with the inactive participants, the hazard ratio (HR) for all-cause mortality was 0.66 (95% CI, 0.62-0.72) in insufficiently active participants who reported 1 to 2 sessions per week, 0.70 (95% CI, 0.60-0.82) in weekend warrior participants, and 0.65 (95% CI, 0.58-0.73) in regularly active participants. Compared with the inactive participants, the HR for CVD mortality was 0.60 (95% CI, 0.52-0.69) in insufficiently active participants who reported 1 or 2 sessions per week, 0.60 (95% CI, 0.45-0.82) in weekend warrior participants, and 0.59 (95% CI, 0.48-0.73) in regularly active participants. Compared with the inactive participants, the HR for cancer mortality was 0.83 (95% CI, 0.73-0.94) in insufficiently active participants who reported 1 or 2 sessions per week, 0.82 (95% CI, 0.63-1.06) in weekend warrior participants, and 0.79 (95% CI, 0.66-0.94) in regularly active participants.

CONCLUSIONS AND RELEVANCE Weekend warrior and other leisure time physical activity patterns characterized by 1 or 2 sessions per week may be sufficient to reduce all-cause, CVD, and cancer mortality risks regardless of adherence to prevailing physical activity guidelines.

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Leisure time physical activity is associated with reduced risks for mortality from all causes, cardiovascular disease (CVD), and cancer.[1] The World Health Organization recommends that individuals aged 18 to 64 years should perform at least 150 min/wk of moderate-intensity aerobic activity, at least 75 min/wk of vigorous-intensity aerobic activity, or equivalent combinations.[2] More research is needed to determine how frequency, intensity, and duration of activity might best be combined to achieve health benefits.[3] The frequency of activity is not specified, and one could meet prevailing guidelines by taking part in 30 minutes of moderate-intensity physical activity on 5 days of the week or 75 minutes of vigorous-intensity physical activity on 1 day of the week. Those who choose to do all their exercise on 1 or 2 days of the week have been termed *weekend warriors*.[4]

Although less frequent bouts of activity might be more easily fit into a busy lifestyle, little is known about the benefits of the weekend warrior physical activity pattern.[4] Data from the seminal Harvard Alumni Health Study suggest that all-cause mortality risk might be lower in weekend warriors than in sedentary men.[4] Seventy-three deaths occurred in the 580 weekend warriors in the Harvard Alumni Health Study, and the authors acknowledged limited statistical power to investigate mortality risk in the weekend warrior, insufficient, and regular physical activity patterns.[4] Because cardiovascular disease and cancer are among the leading causes of death,[5] the primary objective of the present study was to investigate associations between physical activity patterns and all-cause, CVD, and cancer mortality in a pooled analysis of 11 population-based cohorts. With much greater statistical power than the classic weekend warrior study,[4] the secondary objective of the present study was to investigate how frequency, intensity, and duration of physical activity might influence mortality.

Methods

Participants

The methods used in the Health Survey for England (HSE) and Scottish Health Survey (SHS) are consistent and are described elsewhere.[6,7] Briefly, the HSE and SHS are household-based surveillance studies in which households are selected using a multistage, stratified probability design to be representative of the target populations of the countries. Stratification was based on geographical areas, not individual characteristics; postcode (zip code) sectors were selected at the first stage, and household addresses were selected at the second stage. Participants in the present study were derived from surveys in 1994 (HSE only), 1995 (SHS only), 1997 (HSE only), 1998 (HSE and SHS), 1999 (HSE only), 2003 (HSE and SHS), 2004 (HSE only), 2006 (HSE only), and 2008 (HSE only). Participants 40 years or older were included in the present study for 2 reasons. First, the weekend warrior physical activity pattern was deemed most applicable to busy middle-aged individuals. Second, congenital abnormalities were deemed likely to be responsible for cardiac events in young individuals and lifestyle to be responsible for such events in adults.[8] Local research ethics committees approved all aspects of each survey, and all participants gave written informed consent.

Key Points

Question What are the associations of physical activity patterns with mortality?

Findings This pooled analysis of population-based surveys included 63 591 adult respondents. All-cause mortality risk was approximately 30% lower in active vs inactive adults, including "weekend warrior" respondents who performed the recommended amount of 150 minutes of moderate or 75 minutes of vigorous activity from 1 or 2 sessions per week, insufficiently active respondents who performed less than the recommended amount from 1 or 2 sessions per week, and regularly active respondents who performed the recommended amount from 3 or more sessions per week.

Meaning Weekend warrior, insufficient, and regular physical activity patterns may reduce mortality risk.

Physical Activity

Data were collected from 1994 to 2012. Trained interviewers asked about physical activity. Physical activity was assessed using an established questionnaire that is described elsewhere.[9] Briefly, the interviewer used the questionnaire to inquire about the following aspects of the respondent's physical activity in the 4 weeks before the interview: frequency and duration of participation in domestic physical activity (light and heavy housework, gardening, and do-it-yourself tasks); frequency, duration, and pace of walking (slow, average, brisk, or fast); and participation in sports and exercises using a prompt card showing 10 main groupings, including cycling, swimming, running, football, rugby, tennis, and squash. Six open entries could also be recorded. For each sport and exercise, the respondent was asked to specify frequency, duration, and perceived intensity. The validity[10] and reliability[11] of the physical activity questionnaire are described elsewhere.

In 2175 adults, the Spearman correlation coefficient for accelerometer assessment and questionnaire assessment of moderate- and vigorous-intensity physical activity was 0.38 (95% CI, 0.32-0.45) in men and 0.40 (95% CI, 0.36-0.48) in women.[10] A compendium[12] was used to identify moderate- and vigorous-intensity physical activities in the present study as follows: moderate activities consisted of 3.0 to 5.9 metabolic equivalents (METs), and vigorous activities consisted of 6.0 METs or more, with 1 MET representing resting energy expenditure. Occupational and routine domestic activities were not included in the present analysis. Physical activity patterns were defined as follows: inactive was defined as not reporting any moderate- or vigorous-intensity physical activities; insufficiently active, reporting less than 150 min/wk in moderate-intensity physical activity and less than 75 min/wk in vigorous-intensity physical activity; weekend warrior, reporting at least 150 min/wk in moderate-intensity physical activity or at least 75 min/wk in vigorous-intensity physical activity from 1 or 2 sessions; and regularly active, reporting at least 150 min/wk in moderate-intensity physical activity or at least 75 min/wk in vigorous-intensity physical activity from 3 or more sessions.

Covariates

Trained interviewers asked about age, sex, smoking habit, long-standing illness, occupation, and ethnicity. Participants were asked whether they had any long-standing illness, disability, or infirmity. Socioeconomic status was determined from participants' occupations using the 4-group version of the Registrar General's classification: professional and managerial occupations; skilled nonmanual occupations; skilled manual occupations; and routine and manual occupations. The trained interviewers also measured height and weight, and body mass index (BMI) was expressed as the weight in kilograms divided by the height in meters squared. Trained and qualified nurses measured blood pressure and obtained a nonfasting venous blood sample. Blood pressure was measured 3 times after 5 minutes of seated rest, and the mean of the second and third readings was used. Quality control of blood samples has been described elsewhere.[13] The coefficient of variation of the assays was less than 4%. Obesity was defined as a BMI of at least 30 in the present study. High blood pressure was defined as systolic pressure of at least 140 mm Hg, diastolic pressure of at least 90 mm Hg, or a self-reported physician's diagnosis. A high cholesterol level was defined as a total cholesterol concentration of greater than 193 mg/dL (to convert to millimoles per liter, multiply by 0.0259).

Mortality Follow-up

The British National Health Service Central Registry flagged participants. Data for survivors were censored to the end of 2009 (in the SHS) or the first quarter of 2011 (in the HSE). Diagnoses for the primary cause of death were based on codes from the *International Classification of Diseases, Ninth Revision* (*ICD-9*) and *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision* (*ICD-10*). Codes for CVD mortality were 390 to 459 for *ICD-9* and I01 to I99 for *ICD-10*. Codes for cancer mortality were 140 to 239 for *ICD-9* and C00 to D48 for *ICD-10*.

Statistical Analysis

Data were analyzed in 2016. We used Cox proportional hazards regression models to estimate the associations between physical activity pattern and the risks for all-cause, CVD, and cancer mortality. We examined the proportional hazards assumption by comparing the cumulative hazard plots grouped on exposure, although no appreciable violations were noted. For the present analyses, calendar time (months) was the timescale. We excluded those who died during the first 24 months of follow-up. Investigators[14] have argued that models should include variables that are thought to be important from the literature, whether or not they reach statistical significance in a particular data set. Analyses were adjusted for age and sex (model 1) and further adjusted for smoking habit, long-standing illness, and occupation (model 2). In a series of sensitivity analyses, we adjusted models for CVD at baseline and BMI; we excluded all participants who had physician-diagnosed CVD or cancer at baseline; we investigated participants with obesity and the major risk factors,[15] including smoking, high cholesterol level, and high blood pressure (interactions between the subgroups were investigated); and we adjusted models for survey year. Associations among frequency, intensity, and duration of physical activity and mortality were investigated in secondary analyses. All analyses were performed using SPSS software (version 22; IBM Corp).

Results

We included 63 591 survey respondents (45.9% male; 44.1% female; mean [SD] age, 58.6 [11.9] years) in the present study. **Table 1** shows participants' characteristics at baseline by physical activity classification. Of these, 39 947 (62.8%) were classified as inactive at baseline; 14 224 (22.4%), as insufficiently active; 2341 (3.7%), as weekend warriors; and 7079 (11.1%), as regularly active. The inactive participants tended to be older, to include a higher proportion of smokers, to be in unskilled occupations, and to include a higher proportion reporting long-standing illness. The mean BMI was similar in each group, and more than 90% of participants were white. The weekend warriors included a higher proportion of men. One thousand fifty-three weekend warriors (45.0%) reported taking part in 1 session and 1288 (55.0%) reported taking part in 2 sessions of physical activity per week. Two thousand two hundred one weekend warriors (94.0%) and 5309 regularly active individuals (75.0%) reported participating in sports. Seven hundred twenty-six weekend warriors (31.0%) and 5168 regularly active individuals (73.0%) reported participating in walking at a brisk or fast pace. The mean time spent in moderate- or vigorous-intensity physical activity was approximately 300 min/wk for weekend warriors and approximately 450 min/wk in the regularly active participants; however, the proportion of vigorous-intensity physical activity was higher in weekend warriors than the regularly active participants. eTable 1 in the Supplement shows participant age by survey and survey year. eTable 2 in the Supplement shows physical activity volumes by survey and survey year.

A total of 8802 deaths were due to all causes; 2780, due to CVD; and 2526, due to cancer during 561 159 person-years of follow-up (mean [SD], 8.8 [4.4] years) (eTable 3 in the Supplement shows follow-up by survey and survey year). **Table 2** shows the multivariate associations between physical activity patterns and mortality. Compared with the inactive participants, the fully adjusted hazard ratio (HR) for all-cause mortality was 0.69 (95% CI, 0.65-0.74) in the insufficiently active participants, 0.70 (95% CI, 0.60-0.82) in the weekend warrior participants, and 0.65 (95% CI, 0.58-0.73) in the regularly active participants. Compared with the inactive participants, the fully adjusted HR for CVD mortality was 0.63 (95% CI, 0.55-0.72) in the insufficiently active participants, 0.60 (95% CI, 0.45-0.82) in the weekend warrior participants, and 0.59 (95% CI, 0.48-0.73) in the regularly active participants. Compared with the inactive participants, the fully adjusted HR for cancer mortality was 0.86 (95% CI, 0.77-0.96) in the insufficiently active participants, 0.82 (95% CI, 0.63-1.06) in the weekend warrior participants, and 0.79 (95% CI, 0.66-0.94) in the regularly active participants.

Table 3 shows that the fully adjusted HRs for all-cause mortality were similar in men and women. **Table 4** shows the mul-

Table 1. Participants' Characteristics at Baseline[a]

Characteristic	Physical Activity Pattern, No. (%) of Participants[b]			
	Inactive (n = 39 947)	Insufficiently Active (n = 14 224)	Weekend Warrior (n = 2341)	Regularly Active (n = 7079)
Age, mean (SD), y	61.0 (12.3)	54.7 (10.3)	54.2 (10.2)	54.0 (9.8)
Male	18 016 (45.1)	6330 (44.5)	1318 (56.3)	3490 (49.3)
Cigarette smoking				
Never	16 737 (41.9)	7098 (49.9)	1208 (51.6)	3617 (51.1)
Ex smoker	13 143 (32.9)	4566 (32.1)	789 (33.7)	2343 (33.1)
Current	10 067 (25.2)	2560 (18.0)	344 (14.7)	1118 (15.8)
Occupation				
Professional and managerial	1238 (3.1)	910 (6.4)	206 (8.8)	503 (7.1)
Skilled nonmanual	9507 (23.8)	4964 (34.9)	878 (37.5)	2740 (38.7)
Skilled manual	17 697 (44.3)	5704 (40.1)	885 (37.8)	2584 (36.5)
Routine and manual	11 505 (28.8)	2646 (18.6)	372 (15.9)	1253 (17.7)
Long-standing illness	24 288 (60.8)	6557 (46.1)	1070 (45.7)	2789 (39.4)
BMI, mean (SD)[c]	27.8 (5.0)	27.2 (4.4)	27.1 (4.2)	26.4 (4.0)
Ethnicity				
White	36 791 (92.1)	13 399 (94.2)	2140 (91.4)	6860 (96.9)
Black	959 (2.4)	284 (2.0)	70 (3.0)	78 (1.1)
Asian	1678 (4.2)	341 (2.4)	82 (3.5)	85 (1.2)
Chinese or other	519 (1.3)	199 (1.4)	49 (2.1)	566 (0.8)
Leisure time physical activity				
No. of sessions per week, mean (SD)	NA	2 (2)	1 (0.5)	7 (4)
Total, mean (SD), min/wk	NA	60 (40)	304 (237)	449 (454)
Total vigorous-intensity, mean (SD), min/wk	NA	25 (45)	138 (211)	125 (287)
Ratio of vigorous to total, %	NA	0.43	0.46	0.30

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the height in meters squared); NA, not applicable.

[a] Includes 11 cohorts of 63 591 respondents to the Health Survey for England and Scottish Health Survey.

[b] Physical activity patterns were defined as follows: inactive, not reporting any moderate- or vigorous-intensity physical activities; insufficiently active, reporting less than 150 min/wk in moderate-intensity and less than 75 min/wk in vigorous-intensity activities; weekend warrior, reporting at least 150 min/wk in moderate-intensity or at least 75 min/wk in vigorous-intensity activities from 1 or 2 sessions; and regularly active, reporting at least 150 min/wk in moderate-intensity or at least 75 min/wk in vigorous-intensity activities from 3 or more sessions.

[c] Includes 57 388 respondents.

Table 2. Cox Proportional Hazards Regression for Associations Between Physical Activity Pattern and Mortality[a]

Physical Activity Pattern[b]	No. of Events	Mortality, HR (95% CI)		
		All-Cause	CVD	Cancer
No. of events	NA	8802	2780	2526
Adjusted for age and sex				
Inactive	39 947	1 [Reference]	1 [Reference]	1 [Reference]
Insufficiently active	14 224	0.61 (0.57-0.65)	0.56 (0.49-0.64)	0.77 (0.68-0.86)
Weekend warrior	2341	0.60 (0.51-0.70)	0.53 (0.39-0.72)	0.70 (0.54-0.91)
Regularly active	7079	0.56 (0.50-0.62)	0.51 (0.41-0.63)	0.69 (0.57-0.82)
Fully adjusted[c]				
Inactive	39 947	1 [Reference]	1 [Reference]	1 [Reference]
Insufficiently active	14 224	0.69 (0.65-0.74)	0.63 (0.55-0.72)	0.86 (0.77-0.96)
Weekend warrior	2341	0.70 (0.60-0.82)	0.60 (0.45-0.82)	0.82 (0.63-1.06)
Regularly active	7079	0.65 (0.58-0.73)	0.59 (0.48-0.73)	0.79 (0.66-0.94)

Abbreviations: CVD, cardiovascular disease; HR, hazard ratio; NA, not applicable.

[a] Sample included survey participants 40 years or older (N = 63 591). Participants who died during the first 24 months of follow-up were excluded from this analysis.

[b] Physical activity patterns were defined as follows: inactive, not reporting any moderate- or vigorous-intensity physical activities; insufficiently active, reporting less than 150 min/wk in moderate-intensity and less than 75 min/wk in vigorous-intensity activities; weekend warrior, reporting at least 150 min/wk in moderate-intensity or at least 75 min/wk in vigorous-intensity activities from 1 or 2 sessions; and regularly active, reporting at least 150 min/wk in moderate-intensity or at least 75 min/wk in vigorous-intensity activities from 3 or more sessions.

[c] Models were adjusted for age, sex, smoking, occupation, and long-standing illness.

tivariate association between physical activity pattern and mortality, distinguishing between the physical activity frequencies of the insufficiently active group. Compared with the inactive participants, the HR for all-cause mortality was 0.66 (95% CI, 0.62-0.72) in the insufficiently active participants who reported 1 or 2 physical activity sessions per week and 0.82 (95%

CI, 0.72-0.95) in the insufficiently active participants who reported 3 or more physical activity sessions per week. The HRs for CVD and cancer mortality of the insufficiently active participants who reported 1 or 2 sessions per week were similar to those for the entire insufficiently active group in Table 2, but the HRs of the insufficiently active participants who reported 3 or more sessions per week were higher, and associations with CVD (HR, 0.79; 95% CI, 0.60-1.01) and cancer (HR, 0.99; 95% CI, 0.79-1.24) mortality were attenuated. **Table 5** shows the associations between physical activity pattern and mortality, with the insufficiently active participants as the reference category. Reductions in risk were similar in the insufficiently active and weekend warrior participants and were lower in the regularly active participants.

Selected results are reported in the Supplement. eTable 4 in the Supplement shows the association between physical activity and all-cause mortality by survey and survey year. Although variations across the HSE years were seen, no consistent pattern was evident. eTable 5 in the Supplement shows that the associations between physical activity pattern and mortality were similar in the subsample in which CVD and cancer at baseline and BMI were assessed. eTable 6 in the Supplement shows that the associations between physical activity pattern and mortality were similar when participants with physician-diagnosed CVD or cancer at baseline were removed. eTable 7 in the Supplement shows that the associations between physical activity pattern and all-cause mortality were similar in the obese participants and those with major risk factors. We found no significant interactions among the smoking, obesity, cholesterol level, and blood pressure subgroups. eTable 8 in the Supplement shows that the associations between physical activity pattern and mortality were similar after further adjustment for survey year. eTable 9 in the Supplement shows no significant association between physical activity frequency and mortality in those participants meeting the guidelines. In the subsample who re-

Table 3. Cox Proportional Hazards Regression for Associations Between Physical Activity Pattern and All-Cause Mortality by Sex[a]

Physical Activity Pattern[b]	HR (95% CI) Men (n = 29 181)	Women (n = 34 410)
Inactive	1 [Reference]	1 [Reference]
Insufficiently active	0.71 (0.64-0.78)	0.68 (0.71-0.74)
Weekend warrior	0.78 (0.64-0.95)	0.72 (0.55-0.94)
Regularly active	0.63 (0.54-0.73)	0.57 (0.47-0.68)

Abbreviation: HR, hazard ratio.

[a] Models were adjusted for age, smoking, occupation, and long-standing illness.

[b] Physical activity patterns were defined as follows: inactive, not reporting any moderate- or vigorous-intensity physical activities; insufficiently active, reporting less than 150 min/wk in moderate-intensity and less than 75 min/wk in vigorous-intensity activities; weekend warrior, reporting at least 150 min/wk in moderate-intensity or at least 75 min/wk in vigorous-intensity activities from 1 or 2 sessions; and regularly active, reporting at least 150 min/wk in moderate-intensity or at least 75 min/wk in vigorous-intensity activities from 3 or more sessions.

Table 4. Cox Proportional Hazards Regression for Associations Between Physical Activity Pattern and Mortality, Distinguishing Between the Insufficiently Active Groups[a]

Physical Activity Pattern[b]	No.	Mortality, HR (95% CI) All-Cause	CVD	Cancer
Events		8802	2780	2526
Inactive	39 947	1 [Reference]	1 [Reference]	1 [Reference]
Insufficiently active, 1 or 2 sessions	11 067	0.66 (0.62-0.72)	0.60 (0.52-0.69)	0.83 (0.73-0.94)
Insufficiently active, ≥3 sessions	3157	0.82 (0.72-0.95)	0.79 (0.60-1.01)	0.99 (0.79-1.24)
Weekend warrior	2341	0.70 (0.60-0.82)	0.60 (0.45-0.82)	0.82 (0.63-1.06)
Regularly active	7079	0.65 (0.58-0.73)	0.59 (0.48-0.73)	0.79 (0.66-0.94)

Abbreviations: CVD, cardiovascular disease; HR, hazard ratio.

[a] Models adjusted for age, sex, smoking, occupation, and long-standing illness.

[b] Physical activity patterns were defined as follows: inactive, not reporting any moderate- or vigorous-intensity physical activities; insufficiently active, reporting less than 150 min/wk in moderate-intensity and less than 75 min/wk in vigorous-intensity activities; weekend warrior, reporting at least 150 min/wk in moderate-intensity or at least 75 min/wk in vigorous-intensity activities from 1 or 2 sessions; and regularly active, reporting at least 150 min/wk in moderate-intensity or at least 75 min/wk in vigorous-intensity activities from 3 or more sessions.

Table 5. Cox Proportional Hazards for Associations Between Physical Activity Pattern and Mortality, With the Insufficiently Active Participants as the Reference Category

Physical Activity Pattern[a]	No. of Events	Mortality, HR (95% CI)[b] All-Cause	CVD	Cancer
Insufficiently active	14 224	1 [Reference]	1 [Reference]	1 [Reference]
Weekend warrior	2341	1.09 (0.92-1.30)	0.98 (0.71-1.37)	1.11 (0.84-1.36)
Regularly active	7079	0.86 (0.75-0.98)	0.92 (0.71-1.19)	0.80 (0.65-0.98)

Abbreviations: CVD, cardiovascular disease; HR, hazard ratio.

[a] Physical activity patterns were defined as follows: inactive, not reporting any moderate- or vigorous-intensity physical activities; insufficiently active, reporting less than 150 min/wk in moderate-intensity and less than 75 min/wk in vigorous-intensity activities; weekend warrior, reporting at least 150 min/wk in moderate-intensity or at least 75 min/wk in vigorous-intensity activities from 1 or 2 sessions; and regularly active, reporting at least 150 min/wk in moderate-intensity or at least 75 min/wk in vigorous-intensity activities from 3 or more sessions.

[b] Models adjusted for age, sex, smoking, occupation, and long-standing illness.

ported 1 or 2 sessions per week (the weekend warriors), the HR for all-cause mortality was 0.78 (95% CI, 0.60-1.01) in those who reported 3 or more sessions (the rest). eTable 10 in the Supplement shows that no significant association was found between vigorous-intensity physical activity frequency and mortality in those meeting physical activity guidelines. eTable 11 in the Supplement shows an association between physical activity duration and all-cause and cancer mortality in the entire sample but not in the subsample who reported being physically active.

Discussion

The main objective of this study was to investigate associations between leisure time physical activity patterns and mortality. We found that the insufficiently active, weekend warrior, and regularly active patterns were associated with reduced risks for all-cause, CVD, and cancer mortality and that these associations persisted after adjustment for potential confounders or prevalent long-standing disease at baseline. Little was known about the benefits of a low frequency of physical activity. One of the most striking findings in the present study was that 1 or 2 sessions per week of moderate- or vigorous-intensity leisure time physical activity was sufficient to reduce all-cause, CVD, and cancer mortality risks regardless of adherence to prevailing physical activity guidelines.

In their study of 8421 men, Lee and colleagues[4] reported that, compared with the inactive participants, the HR for all-cause mortality was 0.75 (95% CI, 0.62-0.91) in the insufficiently active participants, 0.85 (95% CI, 0.65-1.11) in the weekend warriors, and 0.64 (95% CI, 0.55-0.73) in the regularly active participants. With greater statistical power, our study shows that the risk for all-cause mortality is significantly lower in weekend warriors than the inactive participants. We extend previous findings by showing that the association between the weekend warrior physical activity pattern and all-cause mortality is much the same in men and women. We also extend previous findings by investigating associations between physical activity patterns and CVD and cancer mortality. An important finding in the present study was that all-cause mortality risk was lower in the insufficiently active participants who reported 1 or 2 physical activity sessions per week than in the inactive participants. Walking,[16] running,[17] and other[18,19] freely chosen leisure time physical activities are purposeful[20] and are of moderate and vigorous intensities. The present study suggests that some leisure time physical activity is better than none: that mortality risks were lower in the insufficiently active and the weekend warrior participants than the inactive participants; that the reductions in risk in the insufficiently active and weekend warrior participants were similar; and that, in those who reported meeting physical activity guidelines, frequency and duration did not matter. Some evidence suggests that mortality risks were lowest in the regularly active participants, and the dose-response association in the present study and others[1] might be described as L-shaped.

Physical inactivity costs global health care systems at least US $54 billion per year.[21] The recommended doses of physical activity can be met by manipulating frequency, duration, and intensity. Although the recommended frequency is not specified, inactive adults are suggested to first increase duration and frequency and then increase intensity to achieve the recommended doses of activity while reducing the risk for musculoskeletal injury.[2,22] Regular participation in physical activity has been recommended to control weight, cholesterol concentration, and blood pressure.[22] The present study suggests that less frequent bouts of activity, which might be more easily fit into a busy lifestyle, offer considerable health benefits, even in the obese and those with major risk factors. A particularly encouraging finding was that a physical activity frequency as low as 1 or 2 sessions per week was associated with lower mortality risks, even in the insufficiently active. Millions of people in England enjoy running, cycling, and sports participation at least once per week.[23,24] Our weekend warrior participants undertook a large proportion of vigorous-intensity physical activity, and quality may be more important than quantity.[25] For example, running is a popular vigorous-intensity exercise, and low doses reduce mortality risk.[26] Vigorous-intensity exercise increases cardiorespiratory fitness more than the same amount of moderate-intensity exercise.[27-29] Cardiorespiratory fitness may be a stronger predictor of mortality than physical activity,[30-32] and, in a classic series of experiments, Hickson and colleagues[33-35] showed that cardiorespiratory fitness could be maintained with 2 sessions of vigorous-intensity exercise per week.

Limitations

Our study has some limitations. More than 90% of our participants were white, and the results may not be generalizable to other racial groups. Physical activity was only assessed at baseline, and we cannot account for changes over time. Physical activity was self-reported; however, questionnaires are still regarded as the mainstay of established surveillance studies, such as the HSE and SHS.[36] Occupational physical activity was not assessed; however, we considered occupational social class as a covariate, and, unlike occupational physical activity, leisure time physical activity is discretionary and hence potentially modifiable. The follow-up period was shorter than that of the classic weekend warrior study[4] and was lower in some survey years than others; however, the HRs were much the same after further adjustment for study year. We cannot discount the possibility of reverse causation in which participants with underlying disease are less likely to be physically active; however, we excluded deaths in the first 24 months of follow-up; adjusted for long-standing illness, CVD, and cancer at baseline; and performed sensitivity analyses to address the issue of reverse causation. The risk for musculoskeletal injury was not assessed. Injury may reduce participation[37]; however, we may reasonably assume that most injury-related reductions in participation were short lived because data from former varsity athletes suggest that physical activity must be maintained in later years to reduce chronic disease risk.[38]

Conclusions

This large, statistically powerful study suggests that different leisure time physical activity patterns are associated with reduced risks for all-cause, CVD, and cancer mortality. The weekend warrior and other physical activity patterns characterized by 1 or 2 sessions per week of moderate- or vigorous-intensity physical activity may be sufficient to reduce risks for all-cause, CVD, and cancer mortality regardless of adherence to prevailing physical activity guidelines.

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