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Various Leisure-Time Physical Activities Associated With Widely Divergent Life Expectancies: The Copenhagen City Heart Study

Peter Schnohr, MD, DMSc; James H. O'Keefe, MD; Andreas Holtermann, PhD; Carl J. Lavie, MD; Peter Lange, MD, DMSc; Gorm Boje Jensen, MD, DMSc; and Jacob Louis Marott, MSc

Abstract

Objective: To evaluate the differential improvements in life expectancy associated with participation in various sports.

Patients and Methods: The Copenhagen City Heart Study (CCHS) is a prospective population study that included detailed questionnaires regarding participation in different types of sports and leisure-time physical activity. The 8577 participants were followed for up to 25 years for all-cause mortality from their examination between October 10, 1991, and September 16, 1994, until March 22, 2017. Relative risks were calculated using Cox proportional hazards models with full adjustment for confounding variables.

Results: Multivariable-adjusted life expectancy gains compared with the sedentary group for different sports were as follows: tennis, 9.7 years; badminton, 6.2 years; soccer, 4.7 years; cycling, 3.7 years; swimming, 3.4 years; jogging, 3.2 years; calisthenics, 3.1 years; and health club activities, 1.5 years.

Conclusion: Various sports are associated with markedly different improvements in life expectancy. Because this is an observational study, it remains uncertain whether this relationship is causal. Interestingly, the leisure-time sports that inherently involve more social interaction were associated with the best longevity—a finding that warrants further investigation.

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Substantial evidence over the past 60 years has shown that physical activity (PA) reduces risks for both coronary heart disease (CHD) and all-cause mortality.[1-20] The Copenhagen City Heart Study (CCHS), a prospective cohort study of approximately 20,000 men and women aged 20 to 98 years, reported associations between mortality and walking,[21] cycling,[22] and jogging.[23-26] Both walking and cycling were found to be associated with lower risks for multivariable-adjusted mortality. For joggers, we found a multivariable-adjusted increase in survival, with a U-shaped association between dose of jogging (calibrated by pace, quantity, and frequency of jogging) and all-cause mortality.[25] The dose of running that was most favorable for reducing mortality was jogging 1 to 2.4 h/wk, with no more than 3 running days a week, at a slow or average pace.[26] Several other reports on running or jogging have supported the concept that a moderate dose of exercise is better at conferring longevity and cardiovascular health than minimal or extreme doses of exercise.[2,27-32]

However, the relationship between different leisure-time sports and life expectancy has not been definitively addressed in previous studies.[33,34] Because various sports require markedly different intensities and durations of exercise, muscle groups used, types of muscle contractions (dynamic vs static), and social interactions, they are likely to confer different effects on longevity. The purpose of this study was to evaluate whether the longevity benefit conferred by exercise

From the Copenhagen City Heart Study, Frederiksberg Hospital, Copenhagen, Denmark (P.S., P.L., G.B.J., J.L.M.); Saint Luke's Mid America Heart Institute and University of Missouri-Kansas, Kansas City, MO (J.H.O.); National Research Centre for the Working Environment, Copenhagen, Denmark (A.H.); Department of Cardiovascular Diseases, John Ochsner Heart and Vascular Institute, Ochsner Clinical School, The University of Queensland School of Medicine, New

Affiliations continued at the end of this article.

varies depending on the type of PA in leisure-time (LTPA). The specific sports studied were tennis, badminton, soccer, jogging, cycling, calisthenics, swimming, and health club activities.

PATIENTS AND METHODS

Study Population

The CCHS is a prospective population cohort study initiated in 1976 comprising a random sample from the Copenhagen Population Register of 19,329 white men and women with an age-span of 20 to 93 years. The current study used the third examination from October 10, 1991, to September 16, 1994 (n=10,135). The sampling background and methods have previously been described.[35] Participants were excluded if they had a history of CHD (n=615), stroke (n=362), cancer (n=606), or missing information about LTPA (n=145), leaving 8577 healthy men and women for analyses. All participants gave written informed consent. The study, since its inception, has been independently funded via the Danish Heart Foundation.

Survey Methods

Established procedures and examinations for CHD epidemiological surveys were used.[36] A comprehensive self-administered questionnaire including information about PA levels (eg, sedentary, light activity, moderate activity, and high activity)[35] was completed and checked by the staff. Participation and duration per week regarding 8 different types of exercise were included in the examination from 1991 to 1994 for each of the following sports: tennis, badminton, soccer, jogging, cycling, low-intensity calisthenics (referred to as gymnastics among the Danes), swimming, and health club activities (eg, treadmill, elliptical trainer, and weights). Furthermore, information about alcohol intake, socioeconomic status, diabetes mellitus, self-rated cardiorespiratory fitness (CRF), self-rated muscle strength, self-rated health, social network, and vital exhaustion was reported. Height, weight, and blood pressure measurements (sitting position after a 5-minute rest, using a London School of Hygiene sphygmomanometer) were obtained, as well as an electrocardiogram and comprehensive laboratory blood tests.

End Points

The participants were followed with end point of all-cause mortality from the third examination in 1991-1994 to March 22, 2017, by using the unique personal identification number in the National Central Person Register. Of the 8577 participants, none were lost to follow-up, but 111 (1.3%) were censored at the date of their emigration out of Denmark.

Statistical Analyses

For each of the 8 sports, a Cox proportional hazards regression analysis with age as time-scale and delayed entry was performed with sedentary individuals as the reference group. Participants reporting not being sedentary and not participating in a sport were included in all Cox regression analyses, but results were not reported for this group. Adjustment was done in 2 steps. Model A included adjustment for age, sex, and weekly volume (total duration) of all LTPA; model B included adjustment for age, sex, weekly volume of all LTPA, smoking, education, income, alcohol drinking habits, and diabetes mellitus. In an additional analysis, social network was added to model B as a potential confounder. A sensitivity analysis with stratification on educational level was performed to eliminate potential social status confounding between the sports.

The assumption of proportionality in the Cox regression models was tested with the Lin, Wei, and Ying score process test.[37] Misspecification of the functional form of total volume was tested by plotting this continuous covariate against the cumulative residual and comparing it to random realizations under the model.

The differences in survival between the different sports were estimated by integrating the model-adjusted mean survival curves. These Makuch-Ghali curves are the average of survival curves based on multivariable Cox models calculated 1 individual at a time for the entire population.[38] Bias-corrected bootstrap resampling with 10,000 samples was performed to estimate the survival differences and their 95% CIs. A P value below .05 was considered statistically significant.

TABLE 1. Characteristics According to Different Types of Sports in Leisure-Time for the 5674 Individuals Engaging in At Least 1 Sport[a,b,c]

Characteristic	Sedentary physical activity (N=1042)	Health club activities (N=206)	Swimming (N=936)	Calisthenics (N=1533)	Cycling (N=4833)	Jogging (N=504)	Soccer (N=184)	Badminton (N=388)	Tennis (N=167)	Other activities (N=755)
Age (y)	61±15	45±14	53±15	57±16	52±15	40±12	39±12	44±14	43±14	49±16
Men	45	46	35	20	47	62	95	65	65	48
Smoking										
Never	22	34	28	33	27	39	39	35	33	31
Former	22	29	27	29	25	29	17	21	26	27
Current	56	38	45	38	47	33	44	44	41	43
Alcohol intake										
Never	32	14	15	19	15	9	5	8	4	15
1-14/1-21 drinks/wk	51	76	72	70	69	80	77	74	77	71
>14/>21 drinks/wk	17	10	13	10	16	11	17	18	19	14
Education										
<Middle school	45	14	23	25	26	7	11	8	4	18
Middle school	35	36	38	39	37	25	37	42	22	37
High school	11	25	18	17	17	31	27	24	27	23
University	8	26	21	19	20	37	25	27	48	22
Househod income										
Low	54	26	36	37	31	23	18	23	30	30
Moderate	30	35	36	39	38	37	42	32	23	38
High	16	39	28	24	31	40	39	44	47	32
Diabetes	6	0	3	2	2	1	1	2	1	2
Body mass index (kg/m^2)	27±5	25±3	25±4	24±4	25±4	24±3	25±3	25±3	24±3	25±4
Resting heart rate (bpm)	76±13	69±12	70±12	71±12	72±12	66±12	68±14	69±12	68±12	69±12
Systolic BP (mm Hg)	141±23	128±18	133±21	135±23	134±21	126±15	128±15	130±19	128±16	131±19
BP medication, %	12	4	7	8	7	1	1	5	2	5
Total cholesterol ≥6 mmol/L, %	56	36	47	51	47	26	38	39	30	40

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TABLE 1. Continued

Characteristic	Sedentary physical activity (N=1042)	Health club activities (N=206)	Swimming (N=936)	Calisthenics (N=1533)	Cycling (N=4833)	Jogging (N=504)	Soccer (N=184)	Badminton (N=388)	Tennis (N=167)	Other activities (N=755)
Self-rated cardiorespiratory fitness										
Worse than peers	39	8	8	7	10	4	4	8	4	10
Same as peers	51	45	52	51	58	37	49	53	43	45
Better than peers	10	48	40	42	32	59	48	39	52	44
Self-rated muscle strength										
Worse than peers	35	8	9	10	10	4	4	6	5	7
Same as peers	55	43	59	58	64	52	58	65	55	53
Better than peers	10	49	32	32	26	44	38	29	39	39
Self-rated health										
Terrible/not so good	45	17	17	20	18	10	6	10	6	15
Good	51	65	70	66	72	72	81	77	73	71
Outstanding	4	18	13	14	11	17	13	13	21	14
Vital exhaustion										
Score 0	21	31	33	33	33	34	43	36	40	35
Score 1-4	40	47	46	44	47	49	44	48	52	44
Score 5-9	22	18	16	17	16	13	11	14	5	15
Score 10-17	17	4	4	6	5	4	2	2	2	5
Social network										
0 contact	4	0	1	1	1	1	0	0	0	1
1-2 contacts	41	17	21	26	25	15	14	15	17	23
3-4 contacts	46	54	55	55	54	54	54	57	53	55
≥5 contacts	9	28	23	18	20	30	32	28	30	21

[a]BP = blood pressure; bpm = beats per minute.
[b]Values are presented as mean ± SD or %. Sex-specific cutoff points are used regarding alcohol intake (men: 21 and women: 14).
[c]The first column shows the physical inactive in leisure-time.

All statistical analyses were performed with the free software environment *R* version 3.2.0 (http://cran.r-project.org/).

RESULTS

Baseline characteristics are presented in Table 1. The sedentary participants were older and had characteristics associated with a higher risk of all-cause mortality compared with subjects who participated in at least 1 sport. The characteristics among the physically active individuals also showed some notable differences. For example, tennis players and joggers were more likely to have a university degree, a better self-rated CRF compared with peers, and an outstanding self-rated health.

Out of the 8577 participants, 1042 (12%) reported being sedentary and 5674 (66%) engaged in at least 1 sport. The average weekly volume of all sports was 411 minutes (almost 7 hours), but very large differences were seen between the sports, ranging from 58 minutes among swimmers to 386 min/wk among cyclists. Cyclists spent more than twice the time on their activity compared with the other sports, and cycling was also the most prevalent activity of 56%. Remarkably, 73% of the cyclists spent more than 4 h/wk riding the bike. However, the health club activities group had the longest total duration of all the sports combined, at 599 min/wk (Table 2).

During the follow-up period of 25 years, we registered 4448 deaths. The Figure shows the adjusted all-cause mortality and the survival increase associated with the 8 different sports. The following multivariable-adjusted life expectancy gains were found compared with sedentary lifestyle: tennis, 9.7 years; badminton, 6.2 years; soccer, 4.7 years; cycling, 3.7 years; swimming, 3.4 years; jogging, 3.2 years; calisthenics, 3.1 years; and health club activities, 1.5 years. The hazard ratios (HRs) for other sport activities were 0.66 (95% CI, 0.57-0.77) and 0.76 (95% CI, 0.65-0.89) in model A and B, respectively. Low social network was a risk factor for all-cause mortality, but did not attenuate the association between the different sports and mortality. When we restricted the analysis to only individuals with a university degree, the ranking of various sports according to HRs remained largely unchanged, although the 95% CIs were wider due to smaller

TABLE 2. Dose of Physical Activity According to Different Types of Sports in Leisure-Time for the 5674 Individuals Participating in At Least 1 Sport

Characteristic	Health club activities (N=206)	Swimming (N=936)	Calisthenics (N=1533)	Cycling (N=4833)	Jogging (N=504)	Soccer (N=184)	Badminton (N=388)	Tennis (N=167)	Other activities (N=755)
Number of other activities									
Mean	3±1	3±1	2±1	2±1	3±1	3±1	3±1	3±1	3±1
0	0	0	0	0	0	0	0	0	0
1	13	10	23	50	4	8	10	3	15
2	26	42	44	31	27	39	37	23	40
3	33	34	24	13	36	26	34	37	28
≥4	29	15	9	5	33	28	20	37	17
Duration (min/wk)									
Current activity	148±123	58±50	95±78	386±244	96±88	126±100	92±71	103±87	173±162
All other activities	451±382	414±313	323±303	74±131	453±300	393±331	379±308	419±336	374±325
Total	599±404	472±322	418±323	460±282	549±326	519±352	471±320	521±344	546±370
Duration >4 h/wk	21	1	4	73	7	15	6	11	26
Total duration >4 h/wk	80	71	61	77	84	78	71	79	77

Values are presented as mean ± SD or %.

Covariates	No. of participants	Duration min/wk	All-cause mortality Events	HR (95% CI)	Bias-corrected survival difference (95% CI)
A. Adjusted for age, sex, and weekly volume of all LTPAs					
Sedentary (reference)	1042	–	680	1.00 (reference)	0.0 (reference)
Health club activities	206	148	50	0.64 (0.48-0.85)**	4.4 (1.6-7.2)**
Swimming	936	58	359	0.62 (0.54-0.71)***	4.7 (3.4-6.0)***
Calisthenics	1533	95	701	0.61 (0.54-0.68)***	4.9 (3.8-5.9)***
Cycling	4833	386	1878	0.59 (0.53-0.65)***	5.2 (4.1-6.3)***
Jogging	504	96	74	0.52 (0.41-0.67)***	6.4 (4.1-8.6)***
Soccer	184	126	30	0.50 (0.35-0.73)***	6.6 (3.2-10.0)***
Badminton	388	92	72	0.44 (0.35-0.57)***	7.9 (5.6-10.3)***
Tennis	167	103	23	0.34 (0.22-0.51)***	10.4 (6.8-14.0)***
B. Adjusted for age, sex, weekly volume of all LTPAs, smoking, education, income, drinking habits, and diabetes					
Sedentary (reference)	926	–	629	1.00 (reference)	0.0 (reference)
Health club activities	167	148	45	0.86 (0.63-1.17)	1.5 (−1.3-4.3)
Swimming	804	57	331	0.71 (0.62-0.82)***	3.4 (1.9-4.8)***
Calisthenics	1354	94	670	0.73 (0.65-0.82)***	3.1 (1.9-4.3)***
Cycling	4203	397	1732	0.69 (0.62-0.77)***	3.7 (2.6-4.9)***
Jogging	399	101	64	0.72 (0.55-0.94)*	3.2 (0.6-5.8)*
Soccer	156	132	27	0.61 (0.41-0.90)*	4.7 (1.4-8.1)**
Badminton	314	93	61	0.53 (0.41-0.69)***	6.2 (3.3-9.1)***
Tennis	111	104	16	0.36 (0.22-0.59)***	9.7 (5.6-13.7)***

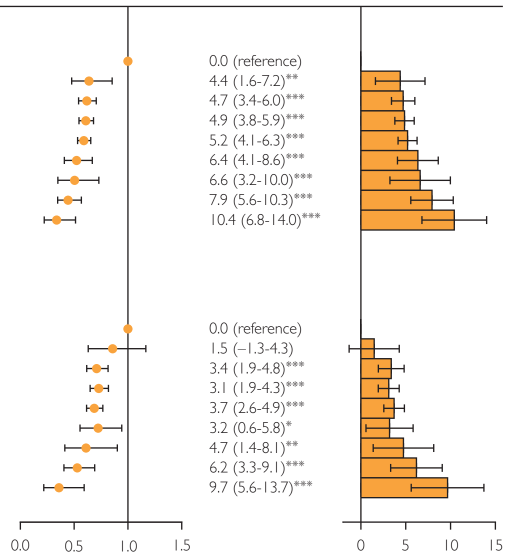

FIGURE. Risk of all-cause mortality in multivariable Cox proportional hazards regression analysis with multivariable-adjusted survival differences for the 5674 individuals engaging in at least 1 sport compared with the 1042 sedentary individuals. The number of individuals engaging in sports sums to more than 5674 because participation in more than 1 sport was common and these different LTPAs were analyzed separately. HR = hazard ratio; LTPA = leisure-time physical activity. *$P<.05$; **$P<.01$; ***$P<.001$.

numbers of individuals. In this subgroup analysis of only individuals with a university degree, tennis (HR, 0.26; 95% CI, 0.10-0.69) and badminton (HR, 0.46; 95% CI, 0.19-1.12) players had the lowest multivariable-adjusted risk of mortality compared with sedentary individuals.

Table 3 presents the pattern of PA according to different types of sports in leisure-time. Cycling is the most frequent activity within each sport and by far the one with the longest duration followed by the sport itself (eg, among tennis players the duration of tennis exceeds the duration of badminton, soccer, etc). Cycling represents 55% to 71% of the total duration in each of the other sports, and the sport itself accounts for approximately 20%.

DISCUSSION

Surprisingly, we found that tennis players had the longest expected lifetime among the 8 different sports. They were followed by badminton players, soccer players, and joggers. By far the smallest improvement in life expectancy was noted in people who predominantly did health club activities (eg, treadmill, elliptical, stair-climber, stationary bikes, and weightlifting). The large differences in life expectancy gains were not accounted for by the wide differences in duration of the various sports, as highlighted by the finding that the cohort of people who spent the most time exercising—health club activities group—was the one that showed the smallest improvement in longevity.

Possibly, the observed differences in mortality benefits were due to the differing social aspects of the various sports studied. Interestingly, sports that require 2 or more individuals to play together and socially interact—tennis, badminton, and soccer—were the sports that were associated with the best improvements in longevity, whereas the less inherently interactive forms of PA, such as jogging, swimming, cycling, and health club activities, were associated with less impressive longevity benefits. This is in line with previous studies consistently showing that social isolation is among the strongest predictors of reduced life expectancy.[39] Sports such as badminton

TABLE 3. Distribution of Physical Activity According to Different Types of Sports in Leisure-Time for the 5674 Individuals Participating in At Least 1 Sport

Characteristic	Health club activities (N=206)	Swimming (N=936)	Calisthenics (N=1533)	Cycling (N=4833)	Jogging (N=504)	Soccer (N=184)	Badminton (N=388)	Tennis (N=167)	Other activities (N=755)
Ranking of activities by participation frequency									
Ranked first / Participation, %	Cycling (76.7)	Cycling (80.4)	Cycling (68.8)	Calisthenics (21.8)	Cycling (88.3)	Cycling (83.2)	Cycling (83.5)	Cycling (87.4)	Cycling (76.0)
Ranked second / Participation, %	Calisthenics (25.2)	Calisthenics (35.9)	Swimming (21.9)	Swimming (15.6)	Calisthenics (27.6)	Jogging (28.8)	Jogging (20.4)	Badminton (29.3)	Calisthenics (23.7)
Ranked third / Participation, %	Swimming (24.8)	Jogging (13.4)	Other activities (11.7)	Other activities (11.9)	Swimming (24.8)	Other activities (21.7)	Calisthenics (15.5)	Jogging (28.1)	Jogging (16.3)
Ranked fourth / Participation, %	Jogging (22.3)	Other activities (12.1)	Jogging (9.1)	Jogging (9.2)	Other activities (24.4)	Badminton (17.9)	Swimming (15.2)	Other activities (21.0)	Swimming (15.0)
Ranked fifth / Participation, %	Other activities (20.9)	Badminton (6.3)	Badminton (3.9)	Badminton (6.7)	Badminton (15.7)	Swimming (11.4)	Other activities (14.9)	Calisthenics (20.4)	Badminton (7.7)
Ranked sixth / Participation, %	Badminton (8.7)	Health club activities (5.4)	Health club activities (3.4)	Health club activities (3.3)	Soccer (10.5)	Tennis (9.8)	Tennis (12.6)	Swimming (18.6)	Health club activities (5.7)
Ranked seventh / Participation, %	Tennis (7.3)	Tennis (3.3)	Tennis (2.2)	Soccer (3.2)	Tennis (9.3)	Calisthenics (8.2)	Soccer (8.5)	Soccer (10.8)	Soccer (5.3)
Ranked eighth / Participation, %	Soccer (4.9)	Soccer (2.2)	Soccer (1.0)	Tennis (3.0)	Health club activities (9.1)	Health club activities (5.4)	Health club activities (4.6)	Health club activities (9.0)	Tennis (4.6)
Ranking of activities according to duration									
Ranked first / % of total duration	Cycling (55.1)	Cycling (71.0)	Cycling (66.4)	Cycling (83.9)	Cycling (59.2)	Cycling (54.7)	Cycling (61.8)	Cycling (54.9)	Cycling (56.3)
Ranked second / % of total duration	Health club activities (24.1)	Swimming (11.8)	Calisthenics (22.5)	Calisthenics (4.4)	Jogging (17.3)	Soccer (24.0)	Badminton (19.3)	Tennis (18.6)	Other activities (29.5)
Ranked third / % of total duration	Calisthenics (5.9)	Calisthenics (7.0)	Other activities (3.9)	Other activities (4.1)	Other activities (7.0)	Other activities (7.0)	Other activities (5.4)	Other activities (7.5)	Calisthenics (5.1)
Ranked fourth / % of total duration	Jogging (4.6)	Other activities (3.8)	Swimming (2.8)	Jogging (1.9)	Calisthenics (5.2)	Jogging (5.8)	Jogging (3.6)	Badminton (4.7)	Jogging (3.0)
Ranked fifth / % of total duration	Other activities (4.0)	Jogging (2.8)	Jogging (2.0)	Swimming (1.8)	Badminton (2.7)	Badminton (3.1)	Calisthenics (3.2)	Jogging (4.5)	Health club activities (1.6)
Ranked sixth / % of total duration	Swimming (2.9)	Health club activities (1.4)	Health club activities (0.9)	Badminton (1.3)	Soccer (2.5)	Health club activities (1.8)	Soccer (2.1)	Calisthenics (4.0)	Swimming (1.6)
Ranked seventh / % of total duration	Badminton (1.6)	Badminton (1.0)	Badminton (0.7)	Health club activities (1.0)	Swimming (2.4)	Calisthenics (1.3)	Swimming (2.0)	Soccer (2.2)	Badminton (1.1)
Ranked eighth / % of total duration	Tennis (1.0)	Soccer (0.6)	Tennis (0.4)	Soccer (0.8)	Health club activities (2.2)	Tennis (1.3)	Tennis (1.7)	Swimming (2.1)	Soccer (1.0)
Ranked ninth / % of total duration	Soccer (0.9)	Tennis (0.6)	Soccer (0.3)	Tennis (0.6)	Tennis (1.5)	Swimming (1.0)	Health club activities (1.0)	Health club activities (1.5)	Tennis (0.7)

and doubles tennis do not typically require strenuous exertion, but do entail a great deal of social interaction. Regular participation in highly interactive sports provides not only exercise but also a social support group that plays together. Belonging to a group that meets regularly promotes a sense of support, trust, and commonality, which has been shown to contribute to a sense of well-being and improved long-term health.[39-41] In addition, benefits of PA and exercise to reduce psychological distress may explain many of the benefits noted regarding cardiovascular disease and mortality.[7,40,42] The smallest improvement in life expectancy was noted in people who predominantly did health club activities. The reason for this could be that their working heart rate was lower than for the other sports, but the reason could also be due to the tendency for people to exercise alone on stationary machines with weights in the health clubs, thereby missing out on the social interaction mandated by racquet sports and soccer, for example.

A scientifically rigorous and widely cited meta-analysis on the topic found that social support had a stronger effect on long-term survival than any other factor, including being a nonsmoker, staying lean, or having normal blood pressure.[43] In that study, having good interpersonal connections conferred twice as much protection against early mortality compared with being physically active. Studies also show that increasing the number of in-person friendships increases one's sense of well-being.[44] If social support and interpersonal relationships exert stronger effects on life expectancy than does exercise, then the highly social but less physically demanding sports such as doubles tennis, badminton, and golf conceivably could be more strongly associated with longevity than more solitary but arduous activities such as running, cycling, stationary exercise machines, and swimming.

Alternatively, the divergent improvements in life expectancy might be accounted for by the differing forms of PA required by the various sports. The sports that were linked to the best life expectancy gains typically require interval bursts of exercise using large muscle groups and full body movements, whereas the sports typically performed in a continuous manner showed less impressive life expectancy gains. This is supported by intervention studies for augmenting CRF, in which activities such as soccer showed better improvements than did a regimen of continuous running.[45] Furthermore, a growing body of evidence indicates that short repeated intervals of higher intensity exercise appear to be superior to continuous moderate intensity PA for improving health outcomes.[46] Cycling as a competitive sport qualifies as high intensity but generally is performed at only low-to-moderate intensity when used for commuting to work. Roughly 40% of the Copenhageners commute to work via bicycle.[47]

Previously, we analyzed the CCHS cohort focusing on 1098 healthy joggers followed for 12 years, and found a U-shaped association between pace, quantity, and frequency of jogging and all-cause mortality. In that previous analysis, the lowest mortality was found in light joggers (HR, 0.22; 95% CI, 0.10-0.47); they had a slow or average pace (<2.5 h/wk and ≤3 times per week) followed by moderate joggers (HR, 0.66; 95% CI, 0.32-1.38; slow or average pace, >3 times per week or ≥2.5 h/wk with a frequency of ≤3 times per week; or fast pace, <2.5 h/wk or 2.5-4 h/wk with a frequency of ≤3 times per week), whereas strenuous joggers had a mortality rate not statistically different from that of the sedentary (HR, 1.97; 95% CI, 0.48-8.14; fast pace, >4 hours of jogging per week or 2.5-4 h/wk with a frequency of >3 times per week). The strenuous group was, however, quite small.[26] Other reports on running have likewise emphasized the benefits of relatively low doses of strenuous PA.[1-19,21-31,42] It should be emphasized that even slow jogging (6 metabolic equivalents) corresponds to vigorous exercise and that strenuous running corresponds to very heavy vigorous exercise (≥12 metabolic equivalents). In the present analyses, the joggers' average life gain was only 3.2 years compared with tennis players' life gain of 9.7 years, raising the possibility that moderate exercise may be better for improving life expectancy than more strenuous exercise.[48]

There is only one other study that analyzed the associations of various types of exercise with all-cause mortality.[33,34] That study population comprised 80,306 men and women from the United Kingdom. The participants were randomly drawn from several samples taken from The Health Survey for England and the Scottish Health Survey. In that study, because the mortality rates of the different types of sports were drawn from several samples, the comparisons between sports are less reliable, and the observed mortality differences between the sports could in fact just reflect differences in mortality of the different populations sampled. However, they did have estimates available for duration, frequency, and intensity of the different sports. As in our study, the UK study showed that the most robust reduction in all-cause mortality was noted for participation in racquet sports (HR, 0.53; 95% CI, 0.40-0.69); considerable reductions in all-cause mortality were also noted for swimming (HR, 0.72; 95% CI, 0.65-0.80) and aerobics (HR, 0.73; 95% CI, 0.63-0.85). In contrast to our study, the UK study reported unimportant associations with mortality for soccer (HR, 0.82; 95% CI, 0.61-1.11) and running (HR, 0.87; 95% CI, 0.68-1.11).[33,34]

Other studies show that golf is another sport that is associated with robust health benefits.[49] One very large observational study found that playing golf on a regular basis improved life expectancy by about 5 years.[50]

Strengths of the present study included the prospective design, the large size of a random sample of both men and women representative of the population of Copenhagen, the detailed information about potential confounding variables, and the 100% follow-up.

Limitations of the study must also be considered. The ideal would have been that the participants in different sports only participated in a single sport. Unfortunately, this was not the case, because all major sports were associated with other kinds of sports although generally to a much lesser degree. We suggest that the 8 different sports analyzed, each representing around 20% or more of the total duration, represent a distinct characteristic that can be used to compare the different sports. Regarding health club activities, we were not able to separate the time spent on aerobic exercise or anaerobic exercise because these activities include treadmill, elliptical, stair-climber, stationary bikes, weightlifting, and so forth.

Although several authors have found that observational studies and randomized controlled studies usually produce similar results, our study was observational and not a randomized trial, and therefore, we cannot be sure that the associations observed in our study represent a causal relationship.[51] Baseline differences among the participants of the various sports and residual confounding could also partly explain the wide range of gains in life expectancy.[33] For example, previous epidemiological studies consistently show that education is strongly positively associated with life expectancy.[52] We have tried to address this issue by comparing the mortality risk across the 8 sports for individuals with a university degree, and tennis players still had the lowest risk of mortality.

CONCLUSION

All forms of LTPA studied were associated with improved life expectancy; however, a wide range in benefit was seen among the various sports. Because this is an observational study, it remains uncertain whether this relationship is causal or merely an association. Interestingly, sports with more social interaction appeared to be associated with the greatest longevity; therefore, the impact of social interaction during LTPA appears to warrant additional study.

Abbreviations and Acronyms: **CCHS** = Copenhagen City Heart Study; **CHD** = coronary heart disease; **CRF** = cardiorespiratory fitness; **HR** = hazard ratio; **LTPA** = leisure-time physical activity; **PA** = physical activity

Affiliations (Continued from the first page of this article.): Orleans, LA (C.J.L.); and Department of Respiratory Medicine, Section of Social Medicine, Institute of Public Health (P.L.) and Medical Department O, Herlev-Gentofte Hospital, University of Copenhagen (P.L.), Copenhagen, Denmark.

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Correspondence: Address to Peter Schnohr, The Copenhagen City Heart Study, Bispebjerg-Frederiksberg Hospital, Nordre Fasanvej 57, DK-2000 Copenhagen, Denmark (peter@schnohr.dk).

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