Atrial fibrillation and physical activity

Should we exercise caution?

N. John Bosomworth MD CCFP FCFP

Abstract

Objective To review the evidence on the effects of various levels of physical activity (PA) on the incidence of atrial fibrillation (AF) in both the general population and in endurance athletes.

Data sources A PubMed search was done initially using the MeSH headings or text words (with the search-field descriptor *TIAB* [title and abstract]) *atrial fibrillation* and *exercise* or *physical activity* or *athlet** or *sport**, without additional filters. Conclusions regarding quality and strength of evidence were based on the GRADE (grading of recommendations, assessment, development, and evaluation) system.

Study selection No interventional studies were available. Observational studies were therefore considered acceptable, and, although larger long-term prospective cohort studies were preferred, case-control or cross-sectional trials were also included in this review.

Synthesis Available evidence suggests a dose-response association linking increased exercise levels with reduced incident AF in women. The same is true in men at low and moderate levels of exertional activity. In men only, high levels of PA are associated with increased risk of AF in most, but not all, studies. This risk is moderate, with a hazard ratio of 1.29 in one of the better studies. The risk of AF for most people who exercise regularly is lower than that of a matched sedentary population.

Conclusion Atrial fibrillation is probably less common as PA increases, with a demonstrable dose-response relationship. Exercise at any level should be promoted for its effect on physical well-being and mortality reduction. In men exercising at high levels, beneficial effects on AF might be lost and risk might exceed that of the sedentary population; however, the evidence is neither robust nor consistent. These men should be made aware of this modest increase in risk should they choose to continue to engage in high levels of PA.

EDITOR'S KEY POINTS

- This review looked at the evidence on the effects of extreme exercise on the incidence of atrial fibrillation (AF) and found there is an association between increasing physical activity and reduced incident AF at low to moderate levels of exercise in men and at all levels of exercise in women.
- In men only, there might be an association between very high physical activity levels and increased incident AF, but the extent of this increase is modest, and there is no effect on mortality.
- Maintenance of an exercise program at any desired intensity should be encouraged to promote well-being and reduce risk of mortality. Men undertaking high levels of endurance activity should be made aware that this is associated with a modest increase in the risk of AF. There is currently no firm threshold or guideline that can be drawn from existing literature.

This article is eligible for Mainpro-M1 credits. To earn credits, go to **www.cfp.ca** and click on the Mainpro link.

This article has been peer reviewed.
Can Fam Physician 2015;61:1061-70

La traduction en français de cet article se trouve à **www.cfp.ca** dans la table des matières du numéro **de décembre 2015** à la **page e542.**

Case description

H.R., a 60-year-old man, visits you in the office. He has been a runner for 20 years and has just completed his 15th marathon. His physical examination findings show no abnormalities and he has an unremarkable medical history. His father had atrial fibrillation (AF) and died following a stroke at the age of 79. Three of his friends in his running club have recently developed AF and have been advised to reduce their levels of exercise. H.R. wants to know whether it is safe to continue his current training schedule of 50 to 60 km per week.

In 1967, Kannel made the following statement: "Prospective epidemiologic studies are hampered by inadequate methods for assessing physical activity, and by a paucity of really physically active adults in the populations under study."[1] In the span of more

than 4 decades since Kannel's observation, a paradox has arisen in the manifestation of physical activity (PA) in North America. Data from the Canadian Health Measures Survey using accelerometry, rather than self-reported estimations, suggest that 69% of adult activity is sedentary.[2] Only 15% of Canadian adults in that survey met or exceeded the World Health Organization's recommendation[3] for leisure-time PA. In contrast, increasing numbers of people are participating in endurance sports[4] and extreme sports.[5]

A recent survey in the United States (US) comparing cohorts from 1988 to 2010[6] shows the sedentary population to have increased from 19.0% to 51.7% in women and from 11.4% to 43.5% in men. On the other hand, marathon participation has increased 140% since 1990 in the US,[4] and the numbers of 24-hour ultramarathon participants have increased, with more female representation and the fastest times being posted by older runners in the 40-to-49 age group.[5] There is a trend to steadily increasing marathon participation by both women (43%) and masters runners older than 40 years of age (47%).[4] Comparable statistics are not available for Canada.

Probably the most accurate estimation of the prevalence of AF comes from a Swedish national registry at 2.9%, last reported in 2010.[7] Prevalence data are not collected for Canada.[8] In the US, estimates are lower and highly variable because of coding inconsistencies[9] and differing database sources.[9-11] Prevalence increases with age in the Swedish registry, rising steeply from 4.2% among those aged 60 to 69 to 13.4% among those aged 80 to 89.[7] General prevalence is also rising, with a relative annual increase of 4.3% to 5%,[9,11] partly owing to aging of the population.

The diagnosis of AF is improving with advances in technology such as implantable loop recorders. However, it is estimated that 10% to 40% of AF might be asymptomatic,[12,13] leading to underestimation of both incidence and prevalence.

This review will look at the effects of extremes of exercise on AF. Because most people are at the low end of the PA spectrum, it might be expected that the beneficial effect of exercise on cardiac risk factors[14] might be helpful in reducing risk of AF. However, there is concern that high-duration or high-intensity PA might increase the risk of AF, and the evidence for this will be examined.

DATA SOURCES

Exercise has total prevalence in that even sedentary people exhibit some PA. This confounder, along with compliance and blinding issues, makes controlled studies difficult.[15]

Study selection

A PubMed search was done initially using the MeSH headings or text words (with the search-field descriptor *TIAB* [title and abstract]) *atrial fibrillation* and *exercise* or *physical activity* or *athlet** or *sport**, without additional filters. Recent available reviews[16-20] and 3 meta-analyses[21-23] were searched for additional trials. Conclusions regarding quality and strength of evidence were based on the GRADE (grading of recommendations, assessment, development, and evaluation) system.[24]

No interventional studies were available. Observational studies were therefore considered acceptable, and, although larger long-term prospective cohort studies were preferred, case-control or cross-sectional trials were also included in this review.

SYNTHESIS

Early studies examining athletes with arrhythmias suggested that most were young, male, and competing at an elite level.[25,26] Approximately 25% of these arrhythmias were AF. Several case-control studies that examined patients presenting with lone AF in arrhythmia clinic[27,28] or emergency department[29] settings followed. Odds ratios for AF in patients engaged in vigorous sports ranged from 3.13 to 15.11 in these studies. Again, most patients were male. Most had paroxysmal AF and predominantly vagal triggers, and, in keeping with the *lone AF* definition, there were no echocardiographic or clinical cardiac abnormalities apart from occasional "mild" hypertension. These studies involved highly selected patients, did not correct for confounding variables, and were at high risk of bias.

Subsequent studies have included the general population and athletes, and have examined patients at all ages, including those with cardiac risk factors and comorbidities.

Cohort studies

In observational literature, cohort studies are the most reliable because they can clarify cause and effect and help determine the incidence and natural history of a condition.[30] Of the available cohort studies listed in **Table 1**,[31-46] the studies by Mozaffarian et al (Cardiovascular Health Study),[35] Aizer et al (Physicians' Health Study),[36] Everett et al (Women's Health Study),[38] and Andersen et al[39] stand out because of appropriate study populations, large participant numbers, and control of various sources of bias.

The Women's Health Study[38] presented a substantial 16% reduction in AF among women who engaged in strenuous PA 1 to 3 times per week, but this advantage was lost with correction for body mass index. No benefit or risk could be demonstrated for the influence of either intensity or frequency of PA on AF. The Cardiovascular Health Study[35] showed a graded reduction in AF progressing from light to moderate PA, but this benefit disappeared with high-intensity exercise; 58% of participants were women. The large Danish Diet,

Table 1. Cohort studies

STUDY	STUDY CHARACTERISTICS	MEAN AGE OF PARTICIPANTS, Y	DEFINITION OF HIGH-INTENSITY EXERCISE AND END POINTS	OUTCOMES	LIMITATIONS	RISK OF BIAS
Karjalainen et al,[31] 1998	• Top-level veteran orienteers (ie, runners) • 228 in orienteer group vs 212 in control group; 100% men • 10-y follow-up	47.5	• High position in veteran ranking is an indicator of y of intense training • Lone AF	• AF developed in 5.3% of orienteers vs 8.9% of control group (RR = 5.5; *P* = .012)	• Men only • Cohort information insufficient • No correction for confounding • Unreliable outcome assessment • Potential recall bias	High
Frost et al,[32] 2005	• Danish Diet, Cancer, and Health Study data • 19 593 (51%) men and 18 807 women • Mean 5.7-y follow-up	56	• Heavy physical workload (self-report) • AF or atrial flutter	• No differences between the sexes* • No differences overall*	• Few subjects exposed to heavy work or vigorous PA • Relied on registry outcomes • Could not separate AF from atrial flutter • Potential recall bias	Moderate
Heidbuchel et al,[33] 2006	• 137 patients after ablation for atrial flutter; 83% men • 31 of the 137 patients regularly engaged in sports before ablation • Mean 2.5-y follow-up	58	• Intense competitive activity ≥ 3 h per wk • Development of AF after ablation for atrial flutter	• AF development in high PA (HR = 1.81; *P* = .02) • No differences between the sexes	• Status after ablation not comparable • Higher rate of cardiovascular disease • Potential for recall bias • No correction for confounding	Moderate
Molina et al,[34] 2008	• 252 Barcelona marathon runners vs 305 sedentary men; 100% men • Retrospective cohort study • Mean 11.6-y follow-up	39	• Marathon running • Lone AF	• Endurance sport practice associated with higher risk of lone AF (HR = 8.80, 95% CI 1.26 to 61.29; *P* = .028)*	• Men only • Control group recruited from different population • 5-y difference in follow-up duration • Risk of recall bias • All AF events not considered	Moderate
Mozaffarian et al,[35] 2008	• Cardiovascular Health Study Medicare eligibility lists in US communities • 5446 participants; 42% men • Post hoc analysis of RCT • 12-y follow-up	73	• ≥ 6 MET† of intensity • ≥ 1840 kcal/wk (self-report) • AF on annual examination or electrocardiogram	• Graded reduction in AF with light to moderate PA intensity* • No reduction in AF with high PA intensity (RR = 0.87, 95% CI 0.64 to 1.19)*	• With an older cohort, there was less high-intensity PA • No sex differences examined	Low
Aizer et al,[36] 2009	• 16 921 men in Physicians' Health Study • Post hoc analysis of RCT • 12-y follow-up	51	• Sufficient to "work up a sweat" 5-7 d/wk (self-report) • AF	• RR for 0 vs 5-7 d/wk (joggers) of vigorous exercise was 1.20 (95% CI 1.02 to 1.41; *P* = .04)* • Elevated risk observed if aged < 50 y (RR = 1.74, 95% CI 1.23 to 2.47; *P* < .01)	• Men only • Some retrospective subgroup analysis • Association seen at 3-y evaluation but not at 9 y	Low
Pelliccia et al,[37] 2010	• 114 Olympic athletes vs 97 people in control group; 78% n • 8.6-y follow-up	22	• Participation in Olympic-endurance disciplines and having multiple games experience • Cardiac symptoms or events	• No cardiac events developed for more than 8 y • Reduced incidence compared with general population	• Very young study cohort • Small group and therefore few potential outcomes • Screening of multiple cardiovascular systems before enrolment • Control group was very fit; had participated in 1 Olympic game	High
Everett et al,[38] 2011	• 34 759 women who had been part of the Women's Health Study • 20-y follow-up	57.5	• ≥ 6 MET† of intensity • ≥ 15 MET† h/wk • AF	• No difference in incident of AF among quintiles after adjusting for hypertension and obesity*	• Women only • Very few women underwent strenuous activity • Self-assessment of PA intensity • Self-assessment of outcomes	Low

Continued on page 1064

Table 1 continued from page 1063

STUDY	STUDY CHARACTERISTICS	MEAN AGE OF PARTICIPANTS, Y	DEFINITION OF HIGH-INTENSITY EXERCISE AND END POINTS	OUTCOMES	LIMITATIONS	RISK OF BIAS
Andersen et al,[39] 2013	• 52 755 Swedish participants in a 90-km cross-country skiing event; 87% men • Mean 9.7-y follow-up	38.5	• Fast finishing time or high number of races completed • AF or atrial flutter	• Higher risk of AF among those who completed >5 races (HR = 1.29, 95% CI 1.04 to 1.61) and among those who had the fastest relative finishing times (HR = 1.20, 95% CI 0.93 to 1.55)*	• Outcomes include AF or atrial flutter • Cohort was still extremely active and not representative of general population	Low
Thelle et al,[40] 2013	• 309 540 Norwegians in a public health screening program; 48% men • 4-y follow-up	41.4	• Frequent hard training or competitive PA • Flecainide prescription	• Increase in AF in men with high intensity PA (HR = 3.14, 95% CI 2.17 to 4.54)*	• High attrition rate over time • Surrogate outcome (flecainide) for lone AF • Self-assessment of PA intensity • Risk of recall bias	Moderate
Williams and Franklin,[41] 2013	• 46 807 participants in the National Runners' and Walkers' Health studies; 41% men • Age range was 33-72 y • 6.2-y follow-up	NA	• ≥6 MET† of intensity • ≥5.4 MET† h/d • Any cardiac arrhythmia	• Arrhythmia risk declined by 4.8% each MET† h/d over baseline for runners and walkers* • Benefit was higher for those aged <50 y	• Self-report of PA intensity • Self-report of physician diagnosis • No differentiation of arrhythmia type • Risk of selection bias • Incomplete statistical reporting	Moderate
Bapat et al,[42] 2014	• Participants from MESA database	NA	• Highest of 3 PA intensity categories was >2383 MET† min/wk • AF	• At highest intensity PA in 1 model, HR = 0.79, 95% CI 0.61 to 1.02; $P<.05$*	• There are insufficient data to properly evaluate this study	High
Drca et al,[43] 2014	• 44 410 Swedish men • Mean follow-up of 12 y	60	• Any leisure-time PA of >5 h/wk • AF or atrial flutter	• Walking or cycling at age 30 y showed benefit in AF reduction • Risk of AF increased at age 30 y for >5 h/wk of PA (RR = 1.19, 95% CI 1.05 to 1.36; $P=.008$)*	• Men only • Risk of recall bias • Self-assessment of PA intensity • Outcomes included AF and atrial flutter	Moderate
Ghorbani et al,[44] 2014	• 28 169 US men • 8-y follow-up	68	• PA >6 MET† with high MET h/wk	• No correlation between AF and PA*	• Men only • Self-assessment of PA intensity • Self-report of physician diagnosis • Participation and dropout rates were unclear	Moderate
Knuiman et al,[45] 2014	• 4267 adults from Busselton, Western Australia; 44% men • 15-y follow-up	52	• Vigorous exercise in a usual week • AF	• Higher level of PA associated with non-significant trend to reduced AF*	• 57% survey response • Self-assessment of PA intensity • Risk of recall bias	Moderate
Myrstad et al,[46] 2014	• 2366 Norwegian men participating in 56-km cross-country ski race vs 1179 men from general population • 9-y follow-up	66	• Endurance PA for >30 min >3 times per wk • AF or atrial flutter	• Increased risk of AF for 10 y of vigorous PA (HR = 1.16, 95% CI 0.06 to 1.28) in skiers*	• Men only • Controls from different population • Self report of recent PA • Risk of selection bias	Moderate

AF—atrial fibrillation, HR—hazard ratio, MESA—Multi-Ethnic Study of Atherosclerosis, MET—metabolic equivalent task, NA—not available, PA—physical activity, RCT—randomized controlled trial, RR—relative risk.

*After adjustment for confounding variables.

†A physiologic measure of energy cost of a physical activity: 1 MET = 1 kcal/kg/h.

Cancer, and Health Study database,[32] composed of 49% women, showed no change in AF incidence with exercise; however, very few participants undertook strenuous exercise. Another large study of runners and walkers[41] demonstrated graded reduction in arrhythmias with increasing PA, with younger participants and women showing the most benefit. Other cohorts that included women showed no effects of PA on AF.[37,40,45] It is reasonable to conclude that in women, increased PA is associated with neutral or reduced risk of AF. Increasing participation in endurance events by women might provide further information.

Larger cohort trials in the general population provide an opportunity to examine the effects of

low- and moderate-level exercise. The Cardiovascular Health Study,[35] which combined women and men, suggested incremental reduction in incident AF going from low to moderate PA levels. An increase was seen at high exercise levels, but risk for these participants was no different than that for non-exercisers (**Figures 1** and **2**).[35,36] With a large cohort of men, Drca et al[43] showed no change in AF among men who continued to exercise for longer intervals; however, for a smaller subset of men who were active more than 5 hours per week at age 30 and subsequently remained active, the relative risk of AF was 1.19. In a study with a very large cohort of men and women, Williams and Franklin[41] suggested a continuous reduction in arrhythmias of 4.8% per metabolic equivalent task hours per day in an aggregate of walkers and runners (**Figure 3**).[41] Arrhythmias were self-reported and not differentiated, but AF was considered to be the largest contributor to symptoms.

Data that show an increase in the risk of AF at the upper extremes of PA have been derived primarily from men, usually functioning at competition level (**Table 2**).[31,34,37,39,46-50] A number of studies in men[31,33,34] and some very large cohorts[36,39,40,46] document an increase in incident AF with increasing levels of activity. Some of these studies include only high-level athletes, so do not consider more modest activity levels.[31,34,39,46] Hazard ratios (HRs) for increased AF range from 1.2 in the Physicians' Health Study[36] to 8.8 among a cohort of marathon runners[34] (**Table 1**).[31-46] Of particular interest is a study by Andersen et al[39]; with a mean follow-up of 9.7 years, this study had 52 755 competitive cross-country skiers who were very fit athletes participating in a 90-km race. Compared with athletes who completed only 1 race, those participants who completed more than 5 races had an increased HR of 1.29 for AF (**Figure 4**).[39] This is a reliable study examining vigorous activity, and it extends the dose-response curve established by cohorts taken from the general population.

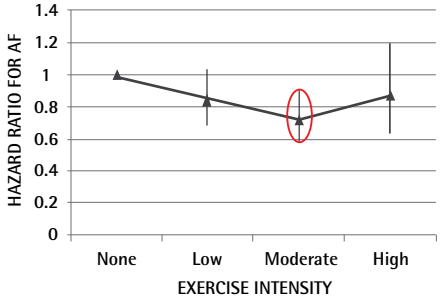
Several trials done in men showed no exercise effect.[32,37,44,45] The larger cohort study by Frost et al[32] considered only work-related PA and might not have been comparable to other studies. Pelliccia et al[37] examined a small population of Olympic athletes with a much lower mean age than in other studies.

Overall, cohort studies of incident AF in men suggest either no effect or a benefit at low and moderate levels of PA. In general population studies (**Figures 1** and **2**),[35,36] there is a suggestion of increased risk at the upper extremes of intensity or frequency of exercise. Of trials done in competitive athletes, all but 1 small cohort[37] suggest an increasing dose response for AF with increasing intensity, frequency, or duration of PA. However, contributing to uncertainty at this level is the Williams and Franklin study,[41] which examines activity outcomes in excess of 3 times the currently recommended exercise level (1.8 metabolic equivalent task hours per day). In spite of the likelihood that some runners in this study (only 41% men) are approaching activity levels seen in elite athletes, a dose–response relationship is seen for arrhythmia reduction at all levels of exercise intensity (**Figure 3**).[41]

Studies in competitive athletes

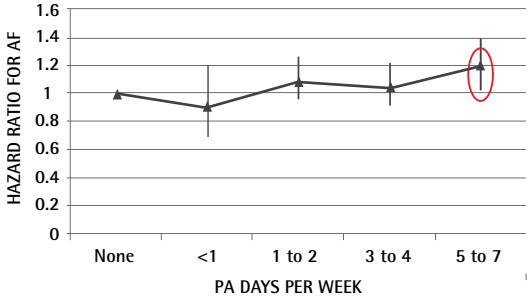
Most available studies evaluating competitive athletes have shown increased risk of AF with higher levels of PA (**Table 2**)[31,34,37,39,46-50]; however, some of these were case-control or cross-sectional studies and had a high risk of bias. The more reliable trials[34,39,49] suggest a HR varying from 1.16 to 8.8 for increased risk of AF, with most of this very heterogeneous group of studies falling closer to the lower end of this range. All but 2 studies[37,39] included only men. The analysis by Andersen et al, noted previously, is likely to be most representative of risk in elite athletes (**Figure 4**).[39]

Figure 1. Cardiovascular Health Study data to determine hazard ratios for AF, by exercise levels: *Circled data point indicates a statistically significant change from baseline.*



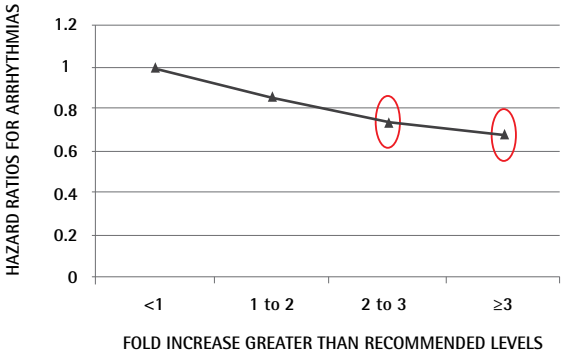
AF—atrial fibrillation.
Data from Mozaffarian et al.[35]

Figure 2. Physicians' Health Study data to determine hazard ratios for AF, by PA per week: *Circled data point indicates a statistically significant change from baseline.*



AF—atrial fibrillation, PA—physical activity.
Data from Aizer et al.[36]

Figure 3. National Walkers' and Runners' Health studies data to determine hazard ratios for arrhythmias: *Circled data points indicate a statistically significant change from baseline.*



Data from Williams and Franklin.[41]

DISCUSSION

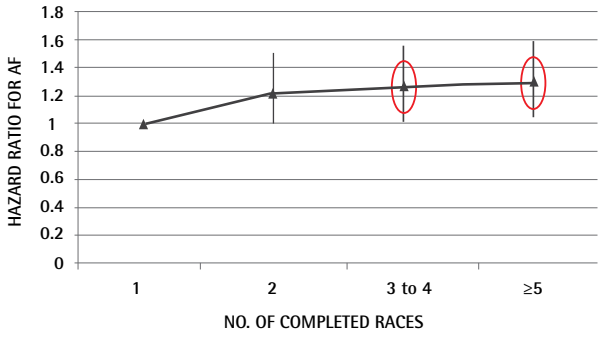
Available evidence suggests a dose-response relationship between increased exercise levels with reduced incident AF in women. The same is true in men at low and moderate levels of exertional activity. In men only, high levels of PA are associated with increased risk of AF in most, but not all, studies. This risk is moderate, with an HR of 1.29 in one of the better studies.[39] Men undertaking high levels of endurance activity should be made aware that this is associated with a modest increase in risk of AF (grade 1C: strong recommendation, low-quality evidence). The risk of AF for most people who exercise regularly is lower than that of a matched sedentary population. There is currently no firm threshold or guideline that can be drawn from existing literature.

Table 2. Studies in athletes

STUDY	STUDY TYPE	TYPE OF ATHLETES	AF OUTCOMES	RISK OF BIAS
Andersen et al,[39] 2013	Cohort	Swedish cross-country skiers for 90-km event	• HR = 1.29 (95% CI 1.04 to 1.61) for > 5 completed races • HR = 1.20 (95% CI 0.93 to 1.55) for those with fastest times • 87% of study participants were men	Low
Baldesberger et al,[47] 2008	Case control	Former Swiss elite cyclists	• AF developed in 10% of cyclist group and in 0% of control group (BGD *P* value of .028) • Study included only men	High
Grimsmo et al,[48] 2010	Cross sectional	Elite-level Norwegian cross-country skiers	• AF prevalence of 16.7% was found • Lone AF prevalence of 12.8% was found • Study included only men	High
Karjalainen et al,[31] 1998	Cohort	Top-level orienteers (runners)	• AF developed in 5.3% of orienteers vs 8.9% of control group (RR = 5.5; *P* = .012) • Study included only men	High
Molina et al,[34] 2008	Retrospective cohort	Runners in Barcelona Marathon	• Endurance sport practice associated with higher risk of lone AF (HR = 8.80, 95% CI 1.26 to 61.29; *P* = .028) • Study included only men	Moderate
Myrstad et al,[46] 2014	Cohort	Norwegian cross-country ski racers for 56-km event	• Increased risk of AF for 10 y of vigorous PA (HR = 1.16, 95% CI 0.06 to 1.28) • Study included only men	Moderate
Myrstad et al,[49] 2014	Cross sectional	Participants in Birkebiner cross-country ski race—a course of 54 km and 1000 m uphill	• AF in men currently practising endurance sport (OR = 1.81, 95% CI 1.04 to 3.14) • Study included only men • 78% of study participants were men	High
Pelliccia et al,[37] 2010	Cohort	Olympic athletes	• No cardiac events developed for more than 8 y • Reduced incidence compared with general population	High
Van Buuren et al,[50] 2012	Cross sectional	Elite German handball players	• AF prevalence of 30.3% in former athletes • Study included men only	High

AF—atrial fibrillation, BGD—between-group difference, HR—hazard ratio, OR—odds ratio, PA—physical activity, RR—risk ratio.

Figure 4. Hazard ratios for AF of competitive skiers, by number of completed races: *Circled data points indicate a statistically significant change from baseline.*



AF—atrial fibrillation.
Data from Andersen et al.[39]

Pathophysiology

There is controversy as to whether changes seen in the cardiac structure and function of athletes represent benign adaptation to the stress of exercise or pathological change producing increased risk of arrhythmias.[51] It is also unclear whether increased atrial ectopy from the pulmonary veins produced by increased PA is the primary cause of observed arrhythmias[16,17] or whether other mechanisms are dominant. Baldesberger and colleagues[47] did not document increased ectopy in their survey of elite cyclists.

Increased vagal tone is present in many endurance athletes.[52] This can lead to bradycardia and reduced atrial refractory period, and serve as a trigger or modulator of heart rhythm by creating conditions for re-entry.

Exercise induces an increase in the pressure of pulmonary arteries, which is especially prominent in athletes.[53] During PA, higher pressure measures are seen in the right atrium and ventricle, with progressive reduction in right ventricular ejection fraction as duration of intense exercise increases.[54] Dilation of the less-muscular chambers of the atria and the right ventricle might result if exercise stress continues and there is insufficient time for recovery, leading, in some people, to microtrauma, inflammation, fibrosis, and potential substrate for arrhythmias.[55] Some authors argue for the presence of an exercise-induced arrhythmogenic right ventricular cardiomyopathy.[53,56]

Despite the speculation summarized in **Figure 5,** no established physiologic mechanism exists to explain any association between high exercise intensity and AF.

Prognosis

High-performance athletes with AF are probably unlikely to have comorbidities. The population subset with these findings is generally men who are younger than age 60 with normal findings on physical examinations, chest x-ray scans, electrocardiograms, and echocardiographic investigations[57]—criteria for the condition previously termed *lone AF*. The effect of exercise on risk factors such as hypertension and glucose intolerance, together with the effect of preselection of healthy people who can better tolerate PA,[18] might predispose athletes to lower cardiovascular risk over time. In one study, paroxysmal AF in the general population progressed to permanent AF in 19% over 10 years.[58] In another study of athletes with AF who were followed for 9 years, paroxysmal AF continued to occur in 56% of them, paroxysmal AF progressed to permanent in 18%, and no symptoms were observed in 26%.[59] While there might be some prognostic value, the term *lone AF* is probably otherwise not useful, as management is mainly focused on thromboembolism prevention and symptom control, as it is for all AF.[60]

The odds ratios for mortality in AF were found in the Framingham study to range between 1.5 and 1.9, with the lowest risk being in men.[61] Available data in athletes with AF show either no change[47] or reduction in cardiovascular and all-cause mortality.[39,62]

Numerous meta-analyses without exception have demonstrated reduction in mortality from 15% to 50% over various time periods as a result of PA.[63-70] This reduction is also seen in studies done specifically on athletes.[62,71] The most marked mortality reduction is seen in progression from sedentary to light activity.[66,70,72-75] At the highest level of exercise intensity there is a suggestion of loss of mortality reduction[76-79]; however, in no case is this risk higher than that of the sedentary population.

Case resolution

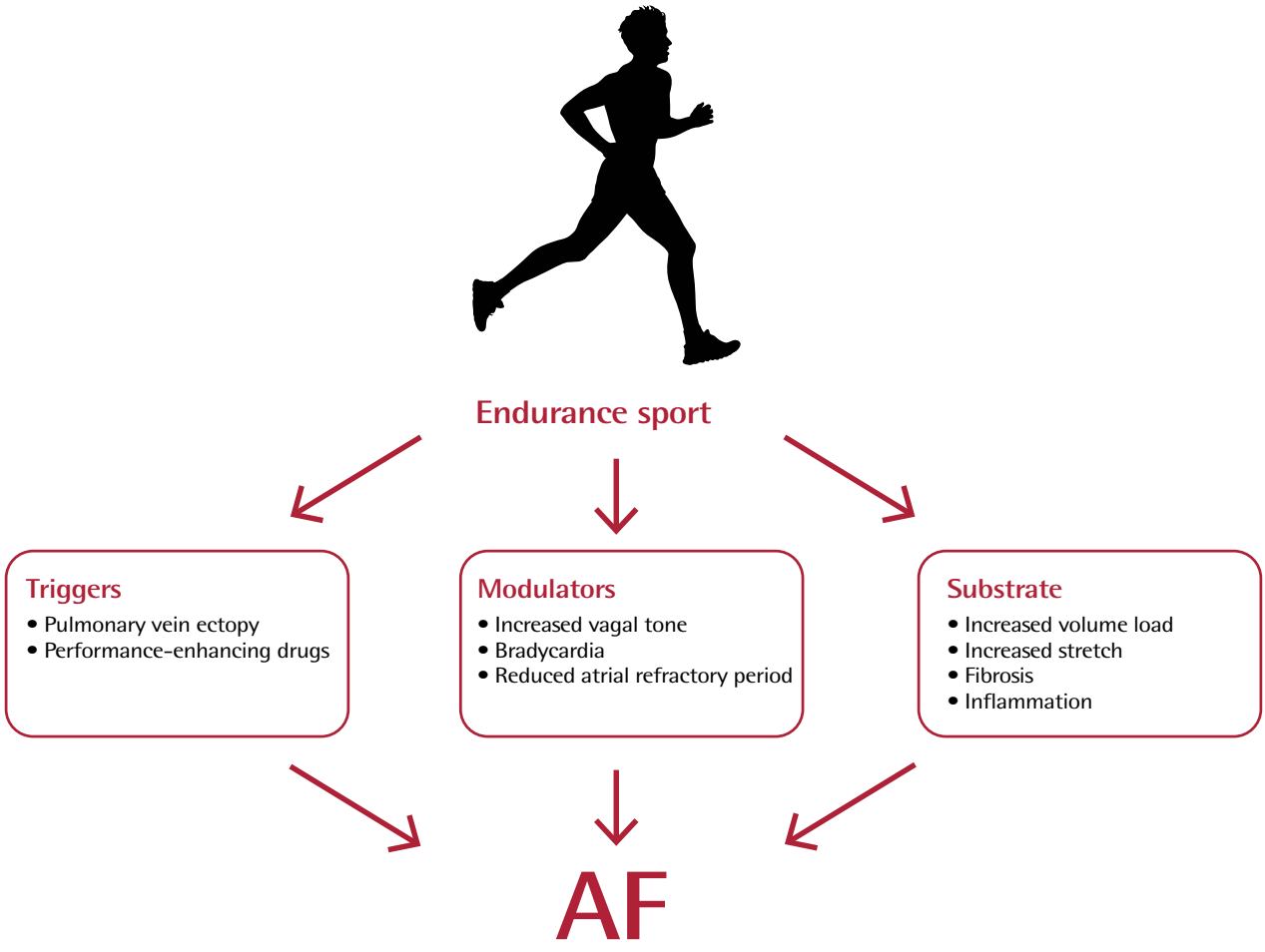
H.R. has no identified risk factors for AF or heart disease and, as a runner, has already self-identified as being at lower relative risk of cardiovascular and all-cause mortality. As a 60-year-old man, H.R. has a 5.7% risk of developing AF.[7] His present activity level might be associated with a 30% increased relative risk of developing AF.[39] His 10-year risk of developing AF might therefore approach 7.4%.

As a land surveyor and mountaineer, H.R. requires a high level of fitness to maintain his quality of life. He elects to continue at his present activity level and accept the modest increased risk this might present. You inform him that a reduction in his activity to moderate levels is associated with a lower-than-average risk of AF with preservation of the health benefits of exercise.

Conclusion

Atrial fibrillation is probably less common as PA increases,

Figure 5. Characteristics of endurance exercise speculated to promote AF



AF—atrial fibrillation.

with a demonstrable dose-response association. Exercise at any level should be promoted for its effect on physical well-being and mortality reduction. In men exercising at high levels, beneficial effects on AF might be lost and risk might exceed that of the sedentary population; however, the evidence is neither robust nor consistent. These men should be made aware of this modest increase in risk should they choose to continue to engage in high levels of PA.

Dr Bosomworth is Honorary Lecturer in the Department of Family Practice at the University of British Columbia in Vancouver.

Competing interests
None declared

Correspondence
Dr N. John Bosomworth; e-mail **jbosomworth@gmail.com**

References

1. Kannel WB. Habitual level of physical activity and risk of coronary heart disease: the Framingham Study. *Can Med Assoc J* 1967;96(12):811-2.
2. Colley RC, Garriguet D, Jannsen I, Craig CL, Clarke J, Tremblay MS. Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep* 2011;22(1):7-14.
3. World Health Organization [website]. *Global strategy on diet, physical activity and health*. Geneva, Switz: World Health Organization; 2015. Available from: **www.who.int/dietphysicalactivity/factsheet_adults/en/**. Accessed 2015 Jun 5.
4. Running USA [website]. *2014 Annual marathon report.* Running USA; 2014. Available from: **www.runningusa.org/index.cfm?fuseaction=news.details&ArticleId=332&returnTo=annual-reports**. Accessed 2014 Dec 5.
5. Zingg M, Rüst CA, Lepers R, Rosemann T, Knechtle B. Master runners dominate 24-h ultramarathons worldwide—a retrospective data analysis from 1998 to 2011. *Extrem Physiol Med* 2013;2(1):21.
6. Ladabaum U, Mannalithara A, Myer PA, Singh G. Obesity, abdominal obesity, physical activity, and caloric intake in US adults: 1988 to 2010. *Am J Med* 2014;127(8):717-27. Epub 2014 Mar 11.
7. Friberg L, Bergfeldt L. Atrial fibrillation prevalence revisited. *J Intern Med* 2013;274(5):461-8. Epub 2013 Aug 7.
8. Heart and Stroke Foundation [website]. *Statistics*. Ottawa, ON: Heart and Stroke Foundation; 2015. Available from: **www.heartandstroke.com/site/c.ikIQLcMWJtE/b.3483991/k.34A8/Statistics.htm#atrialfib.** Accessed 2015 Jun 6.
9. Piccini JP, Hammill BG, Sinner MF, Jensen PN, Hernandez AF, Heckbert SR, et al. Incidence and prevalence of atrial fibrillation and associated mortality among medicare beneficiaries: 1993-2007. *Circ Cardiovasc Qual Outcomes* 2012;5(1):85-93. Epub 2012 Jan 10.
10. Miyasaka Y, Barnes ME, Gersh BJ, Cha SS, Bailey KR, Abhayaratna WP, et al. Secular trends in incidence of atrial fibrillation in Olmsted County, Minnesota, 1980 to 2000, and implications on the projections for future prevalence. *Circulation* 2006;114(2):119-25. Epub 2006 Jul 3.

11. Colilla S, Crow A, Petkun W, Singer DE, Simon T, Liu X. Estimates of current and future incidence and prevalence of atrial fibrillation in the U.S. adult population. *Am J Cardiol* 2013;112(8):1142-7. Epub 2013 Jul 4.
12. Dobreanu D, Svendsen JH, Lewalter T, Hernández-Madrid A, Lip GY, Blomström-Lundqvist C. Current practice for diagnosis and management of silent atrial fibrillation: results of the European Heart Rhythm Association survey. *Europace* 2013;15(8):1223-5.
13. Rho RW, Page RL. Asymptomatic atrial fibrillation. *Prog Cardiovasc Dis* 2005;48(2):79-87.
14. Williams PT. Relationship of distance run per week to coronary heart disease risk factors in 8283 male runners. The National Runners' Health Study. *Arch Intern Med* 1997;157(2):191-8.
15. Paffenbarger RS, Hyde RT. Exercise in the prevention of coronary heart disease. *Prev Med* 1984;13(1):3-22.
16. Calvo N, Brugada J, Sitges M, Mont L. Atrial fibrillation and atrial flutter in athletes. *Br J Sports Med* 2012;46(Suppl 1):i37-43.
17. Delise P, Sitta N, Berton G. Does long-lasting sports practice increase the risk of atrial fibrillation in healthy middle-aged men? Weak suggestions, no objective evidence. *J Cardiovasc Med* (Hagerstown) 2012;13(6):381-5.
18. Graff-Iversen S, Gjesdal K, Jugessur A, Myrstad M, Nystad W, Selmer R, et al. Atrial fibrillation, physical activity and endurance training. *Tidsskr Nor Laegeforen* 2012;132(3):295-9.
19. Müller-Riemenschneider F, Andersohn F, Ernst S, Willich SN. Association of physical activity and atrial fibrillation. *J Phys Act Health* 2012;9(5):605-16. Epub 2011 Jul 29.
20. Wilhelm M. Atrial fibrillation in endurance athletes. *Eur J Prev Cardiol* 2014;21(8):1040-8. Epub 2013 Jan 30.
21. Abdulla J, Nielsen JR. Is the risk of atrial fibrillation higher in athletes than in the general population? A systematic review and meta-analysis. *Europace* 2009;11(9):1156-9. Epub 2009 Jul 24.
22. Ofman P, Khawaja O, Rahilly-Tierney CR, Peralta A, Hoffmeister P, Reynolds MR, et al. Regular physical activity and risk of atrial fibrillation: a systematic review and meta-analysis. *Circ Arrhythm Electrophysiol* 2013;6(2):252-6. Epub 2013 Mar 20.
23. Kwok CS, Anderson SG, Myint PK, Mamas MA, Loke YK. Physical activity and incidence of atrial fibrillation: a systematic review and meta-analysis. *Int J Cardiol* 2014;177(2):467-76.
24. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008;336(7650):924-6.
25. Coelho A, Palileo E, Ashley W, Swiryn S, Petropoulos AT, Welch WJ, et al. Tachyarrhythmias in young athletes. *J Am Coll Cardiol* 1986;7(1):237-43.
26. Furlanello F, Bertoldi A, Dallago M, Galassi A, Fernando F, Biffi A, et al. Atrial fibrillation in elite athletes. *J Cardiovasc Electrophysiol* 1998;9(8 Suppl):S63-8.
27. Mont L, Sambola A, Brugada J, Vacca M, Marrugat J, Elosua R, et al. Long-lasting sport practice and lone atrial fibrillation. *Eur Heart J* 2002;23(6):477-82.
28. Elosua R, Arquer A, Mont L, Sambola A, Molina L, García-Morán E, et al. Sport practice and the risk of lone atrial fibrillation: a case-control study. *Int J Cardiol* 2006;108(3):332-7. Epub 2005 Jun 16.
29. Mont L, Tamborero D, Elosua R, Molina I, Coll-Vinent B, Sitges M, et al. Physical activity, height, and left atrial size are independent risk factors for lone atrial fibrillation in middle-aged healthy individuals. *Europace* 2008;10(1):15-20. Epub 2008 Jan 4.
30. Mann CJ. Observational research methods. Research design II: cohort, cross sectional, and case-control studies. *Emerg Med J* 2003;20(1):54-60.
31. Karjalainen J, Kujala UM, Kaprio J, Sarna S, Viitasalo M. Lone atrial fibrillation in vigorously exercising middle aged men: case-control study. *BMJ* 1998;316(7147):1784-5.
32. Frost L, Frost P, Vestergaard P. Work related physical activity and risk of a hospital discharge diagnosis of atrial fibrillation or flutter: the Danish Diet, Cancer, and Health Study. *Occup Environ Med* 2005;62(1):49-53.
33. Heidbuchel H, Anné W, Willems R, Adriaenssens B, Van de Werf F, Ector H. Endurance sports is a risk factor for atrial fibrillation after ablation for atrial flutter. *Int J Cardiol* 2006;107(1):67-72.
34. Molina L, Mont L, Marrugat J, Berruezo A, Brugada J, Bruguera J, et al. Long-term endurance sport practice increases the incidence of lone atrial fibrillation in men: a follow-up study. *Europace* 2008;10(5):618-23. Epub 2008 Apr 4.
35. Mozaffarian D, Furberg CD, Psaty BM, Siscovick D. Physical activity and incidence of atrial fibrillation in older adults: the Cardiovascular Health Study. *Circulation* 2008;118(8):800-7. Epub 2008 Aug 4.
36. Aizer A, Gaziano JM, Cook NR, Manson JE, Buring JE, Albert CM. Relation of vigorous exercise to risk of atrial fibrillation. *Am J Cardiol* 2009;103(11):1572-7. Epub 2009 Apr 22.
37. Pelliccia A, Kinoshita N, Pisicchio C, Quattrini F, Dipaolo FM, Ciardo R, et al. Long-term clinical consequences of intense, uninterrupted endurance training in Olympic athletes. *J Am Coll Cardiol* 2010;55(15):1619-25.
38. Everett BM, Conen D, Buring JE, Moorthy MV, Lee IM, Albert CM. Physical activity and the risk of incident atrial fibrillation in women. *Circ Cardiovasc Qual Outcomes* 2011;4(3):321-7. Epub 2011 Apr 12.
39. Andersen K, Farahmand B, Ahlbom A, Held C, Ljunghall S, Michaëlsson K, et al. Risk of arrhythmias in 52 755 long-distance cross-country skiers: a cohort study. *Eur Heart J* 2013;34(47):3624-31. Epub 2013 Jun 11.
40. Thelle DS, Selmer R, Gjesdal K, Sakshaug S, Jugessur A, Graff-Iversen S, et al. Resting heart rate and physical activity as risk factors for lone atrial fibrillation: a prospective study of 309,540 men and women. *Heart* 2013;99(23):1755-60. Epub 2013 Jun 8.
41. Williams PT, Franklin BA. Reduced incidence of cardiac arrhythmias in walkers and runners. *PLoS One* 2013;8(6):e65302.
42. Bapat A, Nazarian SS, Post WS, Guallar E, Soliman EZ, Heckbert SR, et al. *Physical activity and incident atrial fibrillation: results from the Multi-Ethnic Study of Atherosclerosis*. Poster presented at: 35th Annual Scientific Session, Heart Rhythm Society; 2014 May 7-10; San Francisco, CA.
43. Drca N, Wolk A, Jensen-Urstad M, Larsson SC. Atrial fibrillation is associated with different levels of physical activity levels at different ages in men. *Heart* 2014;100(13):1037-42. Epub 2014 May 14.
44. Ghorbani A, Willett WC, Mozaffarian D. Physical activity and incidence of atrial fibrillation: the Health Professionals Follow-up Study. *Circulation* 2014;129:AP427.
45. Knuiman M, Briffa T, Divitini M, Chew D, Eikelboom J, McQuillan B, et al. A cohort study examination of established and emerging risk factors for atrial fibrillation: the Busselton Health Study. *Eur J Epidemiol* 2014;29(3):181-90. Epub 2014 Jan 4.
46. Myrstad M, Nystad W, Graff-Iversen S, Thelle DS, Stigum H, Aarønæs M, et al. Effect of years of endurance exercise on risk of atrial fibrillation and atrial flutter. *Am J Cardiol* 2014;114(8):1229-33. Epub 2014 Jul 30.
47. Baldesberger S, Bauersfeld U, Candinas R, Seifert B, Zuber M, Ritter M, et al. Sinus node disease and arrhythmias in the long-term follow-up of former professional cyclists. *Eur Heart J* 2008;29(1):71-8. Epub 2007 Dec 7.
48. Grimsmo J, Grundvold I, Maehlum S, Arnesen H. High prevalence of atrial fibrillation in long-term endurance cross-country skiers: echocardiographic findings and possible predictors—a 28-30 years follow-up study. *Eur J Cardiovasc Prev Rehabil* 2010;17(1):100-5.
49. Myrstad M, Løchen ML, Graff-Iversen S, Gulsvik AK, Thelle DS, Stigum H, et al. Increased risk of atrial fibrillation among elderly Norwegian men with a history of long-term endurance sport practice. *Scand J Med Sci Sports* 2014;24(4):e238-44. Epub 2013 Nov 21.
50. Van Buuren F, Mellwig KP, Faber L, Prinz C, Fruend A, Dahm JB, et al. The occurrence of atrial fibrillation in former top-level handball players above the age of 50. *Acta Cardiol* 2012;67(2):213-20.
51. Maron BJ, Pelliccia A. The heart of trained athletes: cardiac remodeling and the risks of sports, including sudden death. *Circulation* 2006;114(15):1633-44.
52. Mont L, Elosua R, Brugada J. Endurance sport practice as a risk factor for atrial fibrillation and atrial flutter. *Europace* 2009;11(1):11-7. Epub 2008 Nov 6.
53. Heidbuchel H, Prior DL, La Gerche A. Ventricular arrhythmias associated with long-term endurance sports: what is the evidence? *Br J Sports Med* 2012;46(Suppl 1):i44-50.
54. La Gerche A, Burns AT, Mooney DJ, Inder WJ, Taylor AJ, Bogaert J, et al. Exercise-induced right ventricular dysfunction and structural remodelling in endurance athletes. *Eur Heart J* 2012;33(8):998-1006. Epub 2011 Dec 6.
55. O'Keefe JH, Patil HR, Lavie CJ, Magalski A, Vogel RA, McCullough PA. Potential adverse cardiovascular effects from excessive endurance exercise. *Mayo Clin Proc* 2012;87(6):587-95. Erratum in: *Mayo Clin Proc* 2012;87(7):704.
56. La Gerche A, Prior DL, Heidbüchel H. Clinical consequences of intense endurance exercise must include assessment of the right ventricle. *J Am Coll Cardiol* 2010;56(15):1263.
57. Chugh SS, Blackshear JL, Shen WK, Hammill SC, Gersh BJ. Epidemiology and natural history of atrial fibrillation: clinical implications. *J Am Coll Cardiol* 2001;37(2):371-8.
58. Potpara TS, Stankovic GR, Beleslin BD, Polovina MM, Marinkovic JM, Ostojic MC, et al. A 12-year follow-up study of patients with newly diagnosed lone atrial fibrillation: implications of arrhythmia progression on prognosis: the Belgrade Atrial Fibrillation study. *Chest* 2012;141(2):339-47. Epub 2011 May 26.
59. Hoogsteen J, Schep G, Van Hemel NM, Van Der Wall EE. Paroxysmal atrial fibrillation in male endurance athletes. A 9-year follow up. *Europace* 2004;6(3):222-8.
60. Wyse DG, Van Gelder IC, Ellinor PT, Go AS, Kalman JM, Narayan SM, et al. Lone atrial fibrillation: does it exist? *J Am Coll Cardiol* 2014;63(17):1715-23. Epub 2014 Feb 12.
61. Benjamin EJ, Wolf PA, D'Agostino RB, Silbershatz H, Kannel WB, Levy D. Impact of atrial fibrillation on the risk of death: the Framingham Heart Study. *Circulation* 1998;98(10):946-52.
62. Farahmand BY, Ahlbom A, Ekblom O, Ekblom B, Hållmarker U, Aronson D, et al. Mortality amongst participants in Vasaloppet: a classical long-distance ski race in Sweden. *J Intern Med* 2003;253(3):276-83.
63. Sattelmair J, Pertman J, Ding EL, Kohl HW 3rd, Haskell W, Lee IM. Dose response between physical activity and risk of coronary heart disease: a meta-analysis. *Circulation* 2011;124(7):789-95. Epub 2011 Aug 1.
64. Woodcock J, Franco OH, Orsini N, Roberts I. Non-vigorous physical activity and all-cause mortality: systematic review and meta-analysis of cohort studies. *Int J Epidemiol* 2011;40(1):121-38. Epub 2010 Jul 14.
65. Samitz G, Egger M, Zwahlen M. Domains of physical activity and all-cause mortality: systematic review and dose-response meta-analysis of cohort studies. *Int J Epidemiol* 2011;40(5):1382-400. Epub 2011 Sep 5.

66. Löllgen H, Böckenhoff A, Knapp G. Physical activity and all-cause mortality: an updated meta-analysis with different intensity categories. *Int J Sports Med* 2009;30(3):213-24. Epub 2009 Feb 6.
67. Hamer M, Chida Y. Active commuting and cardiovascular risk: a meta-analytic review. *Prev Med* 2008;46(1):9-13. Epub 2007 Mar 20.
68. Sofi F, Capalbo A, Cesari F, Abbate R, Gensini GF. Physical activity during leisure time and primary prevention of coronary heart disease: an updated meta-analysis of cohort studies. *Eur J Cardiovasc Prev Rehabil* 2008;15(3):247-57.
69. Li J, Siegrist J. Physical activity and risk of cardiovascular disease—a meta-analysis of prospective cohort studies. *Int J Environ Res Public Health* 2012;9(2):391-407. Epub 2012 Jan 26.
70. Kelly P, Kahlmeier S, Götschi T, Orsini N, Richards J, Roberts N, et al. Systematic review and meta-analysis of reduction in all-cause mortality from walking and cycling and shape of dose response relationship. *Int J Behav Nutr Phys Act* 2014;11:132.
71. Clarke PM, Walter SJ, Hayen A, Mallon WJ, Heijmans J, Studdert DM. Survival of the fittest: retrospective cohort study of the longevity of Olympic medallists in the modern era. *BMJ* 2012;345:e8308.
72. Wen CP, Wai JP, Tsai MK, Yang YC, Cheng TY, Lee MC, et al. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. *Lancet* 2011;378(9798):1244-53. Epub 2011 Aug 16.
73. Blair SN, LaMonte MJ, Nichaman MZ. The evolution of physical activity recommendations: how much is enough? *Am J Clin Nutr* 2004;79(5):913S-20S.
74. Leon AS, Connett J, Jacobs DR Jr, Rauramaa R. Leisure-time physical activity levels and risk of coronary heart disease and death. The Multiple Risk Factor Intervention Trial. *JAMA* 1987;258(17):2388-95.
75. Haskell WL, Montoye HJ, Orenstein D. Physical activity and exercise to achieve health-related physical fitness components. *Public Health Rep* 1985;100(2):202-12.
76. Lee DC, Pate RR, Lavie CJ, Sui X, Church TS, Blair SN. Leisure-time running reduces all-cause and cardiovascular mortality risk. *J Am Coll Cardiol* 2014;64(5):472-81.
77. Schnohr P, Marott JL, Lange P, Jensen GB. Longevity in male and female joggers: the Copenhagen City Heart Study. *Am J Epidemiol* 2013;177(7):683-9. Epub 2013 Feb 28.
78. Williams PT, Thompson PD. Increased cardiovascular disease mortality associated with excessive exercise in heart attack survivors. *Mayo Clin Proc* 2014;89(9):1187-94. Epub 2014 Aug 12.
79. Mons U, Hahmann H, Brenner H. A reverse J-shaped association of leisure time physical activity with prognosis in patients with stable coronary heart disease: evidence from a large cohort with repeated measurements. *Heart* 2014;100(13):1043-9. Epub 2014 May 14.