

Exercise hypertension: Link to myocardial fibrosis in athletes?

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European Journal of Preventive Cardiology
2020, Vol. 27(1) 89–93
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DOI: 10.1177/2047487319868795
journals.sagepub.com/home/cpr



With a series of articles published over the last two years^{1–3} E Tahir and colleagues participate in the debate on potential detrimental consequences for cardiac structure and function related to extensive, strenuous exercise.^{4,5} In order to further study the well-described biological significance of elevated cardiac biomarkers seen after extreme endurance competitions they have investigated triathletes by blood sampling and cardiac magnetic imaging before and after competition (mean race time: 3.3 ± 2.7 h). In the current study published in the *European Journal of Preventive Cardiology*¹ the authors aimed to assess the predictive value of clinical baseline characteristics of their athletes, for example, training history, maximal exercise capacity and exercise blood pressure during ergometry as well as myocardial dimensions and fibrosis assessed by cardiac magnetic resonance imaging (CMR) and correlated these to increases of cardiac biomarkers and impairment of myocardial function or structure during the race.

The data imply good and bad news for endurance (elite) athletes. First, it was found that despite the fact that serum cardiac biomarkers such as troponin T and N-terminal pro-brain natriuretic peptide (NT-proBNP) significantly increased immediately after the race, maximal exercise strain during a triathlon race does not induce acute overt myocardial inflammation or oedema as assessed by CMR.¹ In a way, these data exonerate such extreme exercise since others had generally observed discrete morphological alterations of the myocardium after endurance competitions,^{6,7} including an increase of physiological strain of the myocardium during volume overload, particularly of the right ventricle.^{8,9} The bad news is that Tahir and colleagues revealed a positive late gadolinium enhancement (LGE) in CMR as a correlate for myocardial fibrosis in a large portion of their athlete male population (33%), a finding more pronounced than in previous investigations.^{10–12}

Explanations for the prevalence of myocardial lesions particularly in male athletes are diverse and include genetic predisposition, gender (females are less affected), risk factors for coronary artery disease and coronary ischaemia itself, acute or reactivated myocarditis, pulmonary

artery pressure overload and exercise-induced repetitive micro-injury during prolonged exercise stress.^{13,14} However, most importantly the series of data^{1,3} adds another potential risk factor to the currently discussed ones, the role of exercise blood pressure on myocardial remodelling and determinant for myocardial injury. The current study has revealed that those athletes with positive LGE had a significantly higher maximal exercise blood pressure (30 mmHg higher compared with LGE negative athletes) at similar maximal exercise capacities between groups. Also, early adaptation typical for arterial hypertension such as left ventricular hypertrophy and left atrial enlargement was observed in the LGE positive group.¹ Furthermore, in LGE positive athletes post-race values demonstrated increased left atrial strain as indicated by a trend towards higher NT-proBNP values.¹ These findings are supported by the research group's previous analysis also investigating triathletes, in which peak exercise systolic blood pressure assessed during ergometry before the race and exercise volume during the race were identified as independent predictors of the presence of LGE.³ Summing up these data may lead to the hypothesis that a repetitive volume overload of the myocardium induced by repetitive endurance training sessions of several hours per day over many years will have an impact on vascular and myocardial physiological adaptation as well as pathological remodelling, resulting in a consecutive pressure overload with increased blood pressures during exercise (Figure 1). Whether this will

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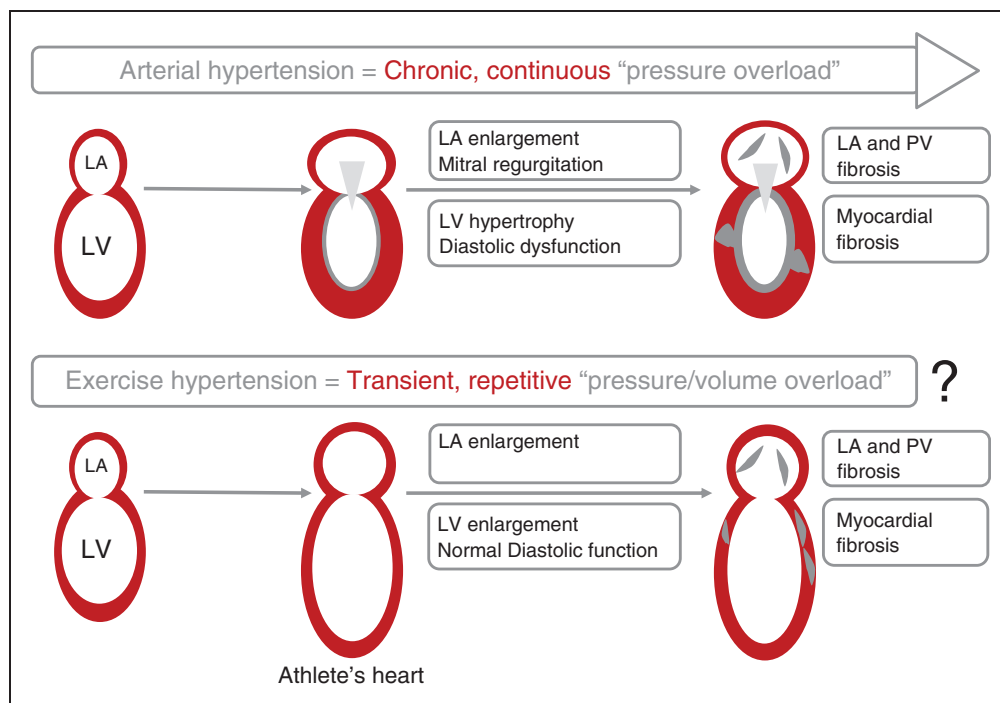


Figure 1. Differences in myocardial adaptation by 'chronic, continuous pressure overload' as in arterial hypertension versus 'transient, repetitive pressure/volume overload' as observed in endurance athletes. It remains unclear whether exercise hypertension over many years of training is the driving risk factor for inducing myocardial injury. LA: left atrium; LV: left ventricle; PV: pulmonary vene.

eventually lead to increased incidence of atrial fibrillation in athletes exposed to long-term exercise remains to be determined.^{15–18}

Among cardiovascular risk factors, arterial hypertension is a key risk factor for coronary artery disease, myocardial dysfunction, left ventricular hypertrophy and remodelling also increasing the risk for clinical events.^{19,20} Even in athletes, hypertension is one of the most common pathologies detected during screening.²¹ The role of hypertensive blood pressure values during exercise, however, is uncertain. Epidemiological data assessing exercise blood pressure have demonstrated an increased risk of subsequent development of arterial hypertension as well as cardiovascular events in those with excessive blood pressure values during exercise.^{22–27} Despite this evidence, it has not been included for risk factor assessment in recent European Society of Cardiology (ESC)/European Society of Hypertension arterial hypertension guidelines.²⁸ Interestingly, elevated blood pressure values during exercise are not uncommon in middle-aged marathon runners²⁹ and especially high exercise values exceeding the recommended maximal exercise values are seen in 43% of males (>210 mmHg) and 28% in females (>190 mmHg).³⁰ Moreover, in middle-aged competitive athletes of different disciplines a higher prevalence of masked hypertension has been

observed.^{31–34} Importantly, very recent data have revealed that higher blood pressure response during exercise was associated with a 3.6-fold increased risk of developing hypertension after 6.5 years of follow-up (26 to 32 years).³⁵ Therefore, current ESC/European Association of Preventive Cardiology hypertension guidelines of the section of sports cardiology have included the entity in their recommendation.^{36,37}

Physiological myocardial adaptation induced by exercise training in athletes is dependent on genetics, family history of hypertension, gender, body composition and exercise volume as well as exercise blood pressure.^{30,38–42} However, the role of exercise blood pressure on myocardial adaptations has been less appreciated in athletes.^{39,40} According to the currently presented and previously published data^{1,3} this will have to be followed more closely and investigated in detail. Even with the current data, though, it is far too early to draw clinical conclusions on treatment of exercise hypertension in athletes. An interesting field of research will have to focus on gender differences between male and female athletes, who have revealed no LGE.³ Whether this finding will be the key explanation for a lower incidence of sudden cardiac death in female athletes will have to be elucidated.⁴³ Moreover, the causality of structural adaptations found in athletes and elevated blood pressure during exercise (chicken

and egg) as well as the mechanistic underpinnings need to be determined.

Nonetheless, timely identification of hypertensive athletes is important in the setting of pre-participation cardiovascular screening in order to implement appropriate non-pharmacological as well as pharmacological management and follow-up.^{36,37} Already today, arterial hypertension is the most common cause for exclusion, at least temporarily, from competitive sport participation.⁴⁴ Therefore, assessment of blood pressure regulation at rest and during exercise is particularly important across the whole age spectrum, particularly the young and the elderly. Important to note is that children and adolescents have lower blood pressure levels with normal values < 120/80 mmHg in those aged 18 and 19 years and even lower values in adolescents.⁴⁵ In elderly master athletes blood pressure regulation independent of pharmacological intervention or after treatment is, however, less clear and should definitely be investigated in upcoming studies. Moreover, the role of supplements, energy drinks, medications (including anti-inflammatory drugs or thyroid hormones for weight reduction), or performance enhancing substances such as erythropoietin and anabolic steroids may be an underestimated cause of secondary hypertension in athletes⁴⁶ and should be explored during the evaluation in athletes with recent and unexplained onset of systemic hypertension.³⁷ If identified, athletes with arterial hypertension should be treated according to the general guidelines for the management of hypertension.⁴⁷

Taken together, E Tahir and colleagues have to be congratulated for addressing an underestimated entity for the physiological as well as pathological adaptation of the myocardium during exercise, the role of arterial exercise hypertension, although it remains unclear whether the data of three publications are partly overlapping.^{1–3} Moreover, from a methodological point of view an observational study such as the present one could go further by adding multivariate analyses or, in the case of quantitative data, respectively adjusted regression analyses. Thus, it remains unclear to what extent the conclusions of Tahir et al. are limited by obvious differences in baseline parameters (seven years of age and a body mass index of 1.7 kg/m²) between the subjects with and without CMR evidence of cardiac fibrosis as well as hidden differences, for example, the years in competitive endurance performance, which have not been reported. Thus, it will remain essential to study exercise blood pressure during training and competition as a so far under-acknowledged matter in endurance athletes.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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