Editorial:

Young Athletes under Pressure?

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Regular participation in exercise has long been known to result in cardiovascular adaptation. Historically, the “athlete’s heart” hypothesis has encouraged a dichotomised view of the heart’s adaptation to sport, depending on whether the physical activity was either of isotonic activity (runners and swimmers) resulting in “cardiomegaly”, or of isometric effort (wrestlers and shot-putters, i.e. ‘strength’ athletes) with clear peripheral adaptations and an “obvious increase in cardiac size” [1]. Today, the classification of sports according to their physiological demands acknowledges a greater diversity of exposure, depending on the physical activity, with an emphasis on a “graded transition” between the main categories: dynamic, static and impact [2]. Still, our understanding of the determinants of structural and functional cardiovascular adaptation to exercise are limited, and the consequences for health remain a matter of debate [3].

In this issue of *Heart*, Hedman *et al.* [4] add to the current knowledge beyond the “athlete’s heart” by presenting data on blood pressure from a large cohort of young athletes. The authors aimed at investigating blood pressure in pre-participation screening, and to evaluate the role of blood pressure against left ventricular (LV) remodelling. Participants’ systolic and diastolic blood pressure was classified according to United States and European hypertension guidelines. They observed that one third of athletes presented with blood pressure exceeding systolic and/or diastolic thresholds of the current US guidelines. Furthermore, systolic blood pressure was associated with LV remodelling and altered diastolic cardiac function, but not systolic function. The findings contribute to our understanding of exercise-induced cardiovascular adaptation, and several important questions arise.

Pre-participation screening is performed in athletic populations to identify silent cardiovascular disease and minimise the risk of triggering future cardiovascular events during exercise. One of the major questions that the study by Hedman *et al*. [4] raises is whether the 34% of young athletes exceeding US thresholds or the 9% exceeding European thresholds require treatment. Irrespective of any discrepancy between the US and European guidelines, clinical decision-making depends on the correct identification of all those at risk, with the intention to subsequently treat them. Importantly, Hedman *et al*. [4] acknowledge that their protocol was not able to capture athletes with white coat and masked hypertension. However, a significant number of young athletes had a systolic blood pressure >130 mmHg and a diastolic blood pressure <80 mmHg. According to the current European guidelines [5], isolated systolic hypertension is defined as a systolic blood pressure >140 mmHg and a diastolic blood pressure <90 mmHg. Therefore, it is likely that some young athletes fell into this category, but the authors did not comment further on these individuals. This is an important omission, given that an estimated 8% of young men in the general population may have isolated systolic hypertension (ISH) of youth [6, 7]. Previous studies have shown that an increased cardiac output may further predispose to ISH of youth, raising the possibility that young athletes who have a significant increase in their stroke volume may have the greatest prevalence, as also indicated by the current article (see Figure 1). The Chicago Heart study revealed that ISH in young individuals increases the risk of subsequent cardiovascular events, suggesting that treating young athletes and non-athletes with ISH may be beneficial. It is therefore unfortunate that the current study did not provide data on either cardiac output or ISH. Similarly, it would have also been useful to include 24h ABMP measurements which are increasingly advocated by members of the American Heart

Association for the diagnosis of hypertension. Clarity on the potential use of performance-enhancing drugs will add further insight into the underlying determinants of young athletes' blood pressure, since the debate around the effects of exercise on cardiovascular health may be clouded by inappropriate behaviour outside the sporting arena. Such data will assist in determining whether the associations between sporting activities and blood pressure presented in the current study are benign or may be early markers of future pathology.

With regard to the discrepancy in hypertension guidelines, Hedman *et al*. [4] provide important data that may shift the discussion away from decision-making by thresholds. The clear linear association between blood pressure and LV mass/volume-ratio at sub-clinical levels indicates that the biological progression occurs on a continuum and applying categorical cut-offs may not be in the best interest. Instead, the data support the need to increase our understanding of specific cardiovascular phenotypes associated with increased blood pressure, in particular in an otherwise low-risk, young population. This is pertinent since increased blood pressure has been shown to be underpinned by different cardiovascular phenotypes as represented by cardiac output and peripheral vascular resistance [8]. Assessing the role of cardiac output in raised blood pressure amongst young athletes may assist in the decision-making for treatment following screening procedures. Just as health concerns have started to be raised in relation to some athletes' hearts, so ISH of youth with its various underlying cardiovascular phenotypes may be far from a "spurious condition" and should be considered for treatment before any end-organ damage [6, 9]. The altered diastolic cardiac function reported by Hedman *et al*. [4] emphasises that an overall phenotype that includes both blood pressure and cardiac function may be the most successful in identifying those at risk from a young age.

Perhaps the most important question is why a minority of young athletes appears to develop cardiovascular maladaptation. It is likely that blood pressure plays a major role in both left- and right-sided (dys)function, although the chicken-or-egg question about which came first remains an enigma (and is likely to be different between individuals). At present, small-scale mechanistic experiments suggest that the healthy heart may be able to sense an acute rise in central aortic pressure via its typical torsional deformation, and subsequently fails to provide the adequate cardiac output [10]. Whether this normal, acute regulatory process is altered in young athletes with a high cardiac output, like those with ISH, is currently a matter of speculation that warrants further investigation. Similarly, discovering a hitherto unreported pulmonary hypertension of youth would fit with the observation that the athlete's right ventricle is disproportionately exposed to high pressures [11], but empirical evidence for such a phenomenon is presently missing.

In summary, Hedman *et al.* [4] are to be commended for their efforts to collect a large data set on young athletes that extends our current knowledge. Their findings highlight the need to follow young athletes longitudinally to determine the role of cardiac output in both LV remodelling, hypertension and ISH of youth. Ideally, this and other work will then be able to provide a sufficient understanding of the cardiovascular adaptation to exercise to identify young athletes at risk beyond the categorisation according to blood pressure guidelines or LV mass index, but instead based upon their overall cardiovascular phenotype. In the future, the "athlete's heart" may have to be known as the "athlete's circulation".

Disclosures

The authors declare that they do not have any relevant financial or other disclosures related to this editorial.

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