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EDITORIAL COMMENT

Cardiac Remodeling in American-Style Football Players

Field Position Matters*

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Athletes are revered by the public and by health care professionals. With increasing physical activity, the performance of most organ systems is enhanced, conferring an overall healthier outlook. The adaptive cardiovascular response to training depends on the type of exercise (1,2). In isotonic exercise, there is enlargement of the cardiac chambers, development of variable degrees of left ventricular (LV) eccentric hypertrophy, and improvement in cardiac performance. In predominantly isometric exercise, LV concentric hypertrophy occurs with an increase in LV mass.

American-style football (ASF) involves various field positions that require different training exercises and inherent body habitus to achieve the desired task. Compared to nonlinemen, linemen usually have a larger body weight, body surface area, and body mass index (BMI); more hypertension and LV mass; and their training and necessary skills require more isometric training than that needed by nonlinemen (3-5). Retrospective data have shown that, although overall survival of ASF players is better than that of controls, linemen may have a worse prognosis than other team members (6). This may be related to development of hypertension, LV hypertrophy, increased BMI, metabolic syndrome, diet, and other factors. Whether the LV hypertrophy observed in linemen (4) is adaptive to physiologic exercise and training or a manifestation of an adverse cardiac remodeling with subtle decrement in LV function, possibly a contributor to adverse outcome, is not known. This was the impetus behind the investigation by Lin et al. (7) in this issue of *iJACC*.

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THE CURRENT STUDY

In this well-designed prospective investigation, the authors studied first-year National Collegiate Athletic Association Division I football players prior to and after their first ASF season (~90 days). Players were evaluated at baseline and within 5 days after the football season, using standard clinical parameters and echocardiography. Echocardiographic measurements consisted of cardiac chamber size, left ventricle (LV) systolic function with conventional ejection fraction, and global longitudinal strain (GLS), a sensitive quantitative measurement of ventricular function. At pre-season, linemen had a larger BMI than nonlinemen. Their blood pressure (BP) and cardiac function parameters were similar. The prevalence of pre-hypertension between the 2 groups was similar (57% and 51%), and no athlete had overt hypertension. After the football season, body weight, body surface area, and BMI further increased in the linemen but not in nonlinemen. Systolic BP increased in both groups but was much higher in linemen: at post season, 60% of linemen had pre-hypertension, and 30% reached stage 1 hypertension, whereas the proportion of pre-hypertension stayed the same in nonlinemen (49%). The football season also resulted in increased LV mass index, more so in linemen; LV hypertrophy was concentric in linemen and eccentric in nonlinemen. While LV ejection fraction did not change in either group, significant differences between GLS were seen in opposite directions: a decrement in linemen versus, an improvement in, nonlinemen. The field position of players, post-season body weight, systolic BP, average wall thickness, and

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relative wall thickness to cavity size were all independent predictors of post-season GLS.

This study was conducted in a rigorous manner: players who undertook training breaks of 3 or more days for any reason were excluded, and adequate GLS signals were required to be obtained in all 6 myocardial segments from the apical 4 chamber view, the reason for the large exclusion of players (103 of 190). Nonetheless, the findings are important and point to a different cardiac adaptive response in linemen compared to young nonlinemen football players after a single first season, which may have significant clinical implications for ASF players.

THE FINDINGS IN CLINICAL CONTEXT

In linemen, the changes in cardiac remodeling of concentric hypertrophy, increase in LV mass, and reduction in GLS are akin to the maladaptive remodeling seen in systemic hypertension and other conditions (8). The use of GLS in the present study provided a more sensitive marker of LV systolic function than ejection fraction and added to the differentiation in cardiac adaptation among players. The reduction in GLS in linemen is likely multifactorial: the type of physical training, mostly isometric; the higher systolic BP; the large baseline BMI, which was even larger after the training season, and all unknown types of diet and dietary supplements consumed may have contributed to the cardiac remodeling and change in GLS. Regardless, the change in GLS points to the fact that, within 1 season, these changes can occur and raise the prospect that this remodeling is likely pathologic and needs to be studied further and addressed.

Other parameters of cardiac function, if available, could have provided further support to the observed maladaptive cardiac findings in linemen. Myocardial deformation during the cardiac cycle occurs in 3-dimensional space and not only in the longitudinal vector. For example, when GLS is reduced in hypertension with preserved ejection fraction reflecting changes in endocardial fibers properties, there is a compensatory increase in radial and circumferential strain accounting for the preserved volumetric function (9). Whether diastolic parameters by tissue Doppler were also affected was not addressed, namely, changes in early mitral annular diastolic velocity (e′), an index of myocardial relaxation. A decrement in myocardial relaxation would further support the abnormality in cardiac function and would give further credence that the changes observed are deleterious. Nonetheless, they are likely to be altered adversely given the observed structural and functional changes.

The study sheds light on health differences within a sports team, depending on the position played, its needs and requirements. The player's position must be viewed in the context of the inherent characteristic milieu of the players, as they are different particularly in ASF. This includes dietary, lifestyle, body habitus, genetics, and physical training requirements. The differences among ASF players by field position in the measurable parameters of BMI, BP, and cardiac adaptations were apparent even after a first, single football season. What are the implications beyond the first year for hypertension, cardiovascular risk, and cardiac remodeling? Do these cardiac changes continue after stopping the training in the off-season and, if yes, for how long? Are the alterations in cardiac remodeling cumulative from one season to another? Can they and should they be modified? These longer term considerations would be important in planning further surveillance of blood pressure and cardiac function in athletes and may prompt alteration in diet, lifestyle, and/or the institution of pharmacotherapy for hypertension if sustained or worsening maladaptation are observed. Whether the adverse cardiac changes account predominantly or in part for the worse long-term prognosis of linemen compared to their nonlinemen colleagues remains to be determined. While questions abound, the current investigation has highlighted this unusual adverse cardiac remodeling in sports with the hope of alerting players and their health care professionals, furthering research, and ultimately addressing ways to protect and improve the health of all athletes in team sports, particularly those who are potentially adversely affected.

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