Impact of American-Style Football Participation on Vascular Function

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Although hypertension is common in American-style football (ASF) players, the presence of concomitant vascular dysfunction has not been previously characterized. We sought to examine the impact of ASF participation on arterial stiffness and to compare metrics of arterial function between collegiate ASF participants and nonathletic collegiate controls. Newly matriculated collegiate athletes were studied longitudinally during a single season of ASF participation and were then compared with healthy undergraduate controls. Arterial stiffness was characterized using applanation tonometry (SphygmoCor). ASF participants ($n = 32$, 18.4 ± 0.5 years) were evenly comprised of Caucasians ($n = 14$, 44%) and African-Americans ($n = 18$, 56%). A single season of ASF participation led to an increase in central aortic pulse pressure (27 ± 4 vs 34 ± 8 mm Hg, $p < 0.001$). Relative to controls ($n = 47$), pulse wave velocity was increased in ASF participants (5.6 ± 0.7 vs 6.2 ± 0.9 m/s, $p = 0.002$). After adjusting for height, weight, body mass index, systolic blood pressure, and diastolic blood pressure, ASF participation was independently predictive of increased pulse wave velocity ($\beta = 0.33$, $p = 0.04$). In conclusion, ASF participation leads to changes in central hemodynamics and increased arterial stiffness. **(Am J Cardiol 2015;115:262−267)**

American-style football (ASF) is the most popular high school team sport in the United States with more than 1 million annual participants.[1,2] Hypertension is common in professional ASF athletes,[3] and recently, the development of hypertension and corollary concentric left ventricular hypertrophy has been prospectively documented during collegiate ASF participation.[4] Hypertension is a well-established cardiovascular risk factor,[5] and increased arterial stiffness serves as an important mechanistic precursor to the development of overt hypertension.[6,7] Although hypertension and other cardiovascular risk factors have been documented in ASF players,[3,4,8,9] rigorous assessment of arterial function and its association with blood pressure has not been performed in this population. We hypothesized that collegiate ASF participants would demonstrate arterial stiffening during their initial season of collegiate ASF participation. To address this hypothesis, we conducted a prospective, longitudinal, case-controlled study to evaluate arterial elasticity and central blood pressure in collegiate ASF participants.

Methods

ASF participants representing 2 National Collegiate Athletic Association (NCAA) Division I programs (Harvard University and Georgia Institute of Technology) were recruited for this study. Freshman ASF participants were recruited from the Harvard Athletic Initiative, an ongoing research program designed to address numerous issues relevant to athletic health and exercise physiology,[4,10,11] and from a newly formed research initiative between Emory University and Georgia Tech. Anthropometric data, demographics, clinical characteristics, blood pressure, and indexes of arterial function were assessed before and after their first competitive collegiate ASF season. An ethnically matched control group was similarly assessed. The Partners Human Research Committee and the Emory Institutional Review Board approved all aspects of the study before initiation, and all subjects provided written informed consent.

The preseason was defined as the time of university matriculation. The postseason was defined as the immediate conclusion of the fall season for each team involved. Anthropometric and clinical data collected at preseason and postseason study visits included age (years), height (cm), weight (kg), body mass index (kg/m^2), current medication use, personal/family history of hypertension,[12] and pre-study period strength and endurance exercise volume (h/wk). Systolic blood pressure (SBP), diastolic blood pressure (DBP), and indexes of arterial function, as measured by applanation tonometry, were assessed as described later. ASF participants and control subjects were required to abstain from exercise for ≥24 hours before data collection time points.

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See page 266 for disclosure information.

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Table 1
Longitudinal profile of the American-style football player cohort

Variable	Pre-Season ASF (N = 32)	Post Season ASF (N = 32)	P-Value
Age (years)	18.4 ± 0.5	-	-
Height (cm)	189 ± 7	-	-
Weight (kg)	107 ± 21	108 ± 20	0.77
Body-Mass Index (kg/m^2)	29.8 ± 4.6	30 ± 4.3	0.78
Caucasian/African-American	14 (44%) / 18 (56%)	-	-
Hypertension	0/32 (0%)	-	-
Endurance Exercise Volume (hours/week)	4.1 ± 2.3	-	-
Strength Exercise Volume (hours/week)	5.8 ± 2.2	-	-
Family History of Hypertension	10/32 (31%)	-	-
Tobacco	0/32 (0%)	-	-
Heart Rate (bpm)	66 ± 12	63 ± 11	0.22
Systolic Blood Pressure (mm Hg)	114 ± 13	123 ± 9	<0.001
Diastolic Blood Pressure (mm Hg)	65 ± 11	71 ± 9	<0.001
Central Aortic Pulse Pressure (mm Hg)	27 ± 4	34 ± 8	<0.001
Pulse Wave Velocity (m/sec)	6.4 ± 1.1	6.2 ± 0.9	0.27

Values expressed as the mean ± SD or n (%).
ASF = American-style football.

Exercise training volume data during the pre-study period, defined as the 8 weeks before baseline assessment, were collected. Training volumes during this pre-study period were characterized by total number of exercise hours per week dedicated to either endurance or strength activities. Endurance activity was defined as running, cycling, swimming, rowing, or using aerobic machine at an effort sustainable for ≥20 minutes. Strength activity was defined as weight lifting, plyometric exercise, and sprint running drills. Field position for each ASF participant was classified as either lineman (LM) or non-lineman (NLM) as previously proposed.[13] Each ASF participant was subject to testing for performance-enhancing drugs as dictated by NCAA standards.

A control cohort comprising ethnically matched, but nonathletic, male undergraduate students from 1 undergraduate institution (Emory University) was recruited and studied in similar fashion. Recruitment was accomplished using study advertisement brochures that were distributed at various campus locations. The control cohort was studied at a single time point that occurred 3 months into the academic calendar to facilitate comparison with ASF participants at the postseason time point. This approach was chosen to ensure that potential determinants of blood pressure and vascular function inherent in both high school (i.e. pubertal development) and the initial collegiate experience (i.e., access to institutional dining services, changes in sleep patterns, and so on) would be reflected in the control group data set.

Blood pressure was measured by one of the study physicians at all study time points using a manual aneroid sphygmomanometer and an appropriately sized cuff. The average of 3 measurements occurred with participants in a seated position after at least 10 minutes of rest. Blood pressure was classified in accordance with the definitions of the Joint National Commission-8 as follows: optimal (SBP <120 mm Hg and DBP <80 mm Hg), prehypertensive (SBP = 120 to 139 mm Hg and/or DBP = 80 to 89 mm Hg), and stage 1 or greater hypertension (SBP ≥140 mm Hg and/or DBP ≥90 mm Hg).[5]

Indexes of arterial stiffness were measured with participants in the supine position by 2 study investigators (JHK and SS) using a high-fidelity applanation tonometer (SphygmoCor; Atcor Medical, New South Wales, Australia), which records sequential high-quality pressure waveforms at peripheral pulse sites. Full details of tonometer technology and measurement algorithms have been previously detailed.[14] Vascular function was characterized using measurements of central aortic pulse pressure (CPP) and pulsewave velocity (PWV) as these are well-validated surrogates of arterial stiffness and corollary cardiovascular disease risk.[15–20] PWV, the gold standard index of arterial stiffness,[14] was measured by acquisition of pressure waveforms within the carotid and femoral arteries and calculated using the "foot-to-foot" method.[21] Adequate tonometric analysis was defined as PWA derivation >80% of the Operator Index and PWV with <10% SD. Studies not meeting these criteria were excluded from the final analysis. Reproducibility studies in our laboratory on 9 subjects on consecutive days demonstrated a coefficient of variation of 3.8% for PWV.[22]

Categorical variables are presented as proportions and continuous variables mean ± SD. The Shapiro-Wilk test was used to determine the normality of distribution. Categorical variables were compared using Fisher's exact test. Continuous variables were assessed with the Student's paired *t* test for normally distributed variables or the Mann-Whitney test for non-normally distributed variables. Linear regression analyses were used to identify factors associated with the postseason PWV. Univariate covariates tested included age, ASF participation, program affiliation, player position (NLM or LM), ethnicity, height, weight, body mass index, prestudy weekly strength and endurance exercise volume, family history of hypertension, SBP, DBP, and heart rate. Univariate covariates with a p value <0.10 were included in a multivariable linear regression analysis. Analyses were performed with SPSS software (version 21.0; SPSS Inc., Chicago, Illinois). A p value ≤0.05 was considered significant.

Results

Of the 50 ASF participants recruited for this study (Harvard, n = 29; Georgia Tech, n = 21), 18 were excluded secondary to the lack of postseason data because of injury (n = 15; 11 from Harvard and 4 from Georgia Tech) or to inadequate tonometric analysis (n = 3; all Harvard). Thus, 32 ASF participants (15 from Harvard and 17 from Georgia Tech) were included in the final longitudinal analysis. No ASF participants crossed over from an LM to an NLM (or vice versa) field position during the study period. Three of the 50 control subjects were excluded from analysis because