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Relationship between proxies for Type II fiber type and resting blood pressure in Division I American Football Athletes

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ABSTRACT

Objective: The risk for cardiovascular disease is well-documented. Perhaps surprisingly, specific athletic populations, including American football players, exhibit increased risk for cardiovascular disease as presented by elevated blood pressure. There is evidence suggesting a link between muscle fiber type distribution and resting blood pressure. Acknowledging this association, it becomes important to clarify an individual's risk for developing cardiovascular disease later in adulthood. The purpose of this study was to assess football performance measures—in particular proxies for muscular power—and their effect on resting blood pressure in football athletes.

Methods: A total of 80 collegiate-level football players participated in this study. Each participant's body fat %, body mass index, waist circumference, and mean arterial pressure (MAP) were measured. Participants performed one-repetition maximums of bench press, back squat, 40-yard dash, and vertical leap, and a power index (PI) defined as the product of vertical leap and mass. Linear regressions were run between body composition variables and performance measures for all players and a subset of skill players only.

Results: The PI was found to be positively, significantly correlated with MAP in all players ($r = 0.269$; $P = 0.035$) and the skill players subset ($r = 0.425$; $P = 0.004$).

Conclusion: The results of the present study indicate an association between muscle fiber type distribution, as indicated by muscular power capacity, and resting blood pressure.

Keywords: Fiber type composition, anaerobic metabolism, hypertension, cardiovascular disease

Introduction

The risk for cardiovascular disease associated with high body mass index (BMI) and has been documented in a variety of investigations.[1] Perhaps, surprisingly, this has also been the case with certain athletic populations, including collegiate and professional American football players.[2-6] Despite the fact that football athletes regularly engage in intense levels of physical activity, these individuals presenting with high BMIs also show increased risk of cardiovascular disease as reflected by elevated blood pressure.[2-5] Men who have elevated blood pressure at a young age have been positively associated with an increase in morbidity and mortality related to cardiovascular disease later in adulthood;[7] thus, the ability to assess risk for cardiovascular disease becomes important at a young age. Hypertension has been linked to excess body weight, reduced physical activity, excess dietary sodium and alcohol intake, and inadequate consumption of fruits and vegetables.[8] However, several lines of research have also shown that hypertensive patients, compared to their normotensive peers, tend to have a higher proportion of Type II muscle fibers, irrespective of body type and fitness level.[9,10] This suggests that muscle fiber type distribution may have an effect on resting blood pressure, and in certain populations—such as elite American football players—this may contribute to increased risk for cardiovascular disease.

The nature of American football favors individuals who can produce muscular force rapidly and efficiently. Given the physiological and tactical demands of the sport, it may be reasonably assumed that elite-level players are characterized by muscle fiber type distributions that allow them to meet these physical demands at an exceptional level. Elite football players likely possess higher percentages of Type II, or fast-twitch muscle fibers, partly because these fibers have a higher peak rate of force development and twitch/tetanus ratio than Type I, or slow-twitch muscle fibers.[11] Acknowledging the association between hypertension and cardiovascular disease,[7,12] and given the increased focus on cardiovascular health in American football players,[2-5] it is important to understand the relationship between muscle fiber type distribution and resting blood pressure, specifically because it may help clarify the risk for cardiovascular disease in specialized athletic populations.

The purpose of this study was to examine the relationship between muscle fiber type distribution and resting blood pressure in collegiate-level football players by systematically assessing standards of football performance, with a specific emphasis on proxies for muscular power and their effect(s) on resting blood pressure. We hypothesized that collegiate football players would exhibit higher resting blood pressure with increasing muscular power capacity.

Methods

This is a descriptive study, in which proxies for fast-twitch muscle fibers were used to predict resting blood pressure, reported as mean arterial pressure (MAP). Muscular power capacity was assessed using a power index (PI) variable (POWER) defined as the product of vertical leap (m) and mass (kg). Vertical leap has been previously shown to be a reliable indicator of muscle fiber type distribution.

Subjects

Collegiate football players who were listed on the varsity roster during the 2007 football season at a public university in the Mid-American Conference of the National Collegiate Athletic Association were recruited to participate in this study. Inclusion criteria for this study included >18 years of age. Exclusion criteria for this study included any history of smoking, diabetes, cardiovascular disease, cardiomyopathy, or hypercholesterolemia, or were otherwise unable to provide informed consent. All of the 105 players listed on the varsity roster met the inclusion criteria, and none were excluded from the study. Of the 105 eligible players, 80 players (mean ± standard deviation age, 19.8 ± 1.4 years; mass, 99.3 ± 16.9 kg) volunteered for participation. Anthropometric data were collected over the course of 2 weeks during the season. Strength and power performance data were collected on two separate, consecutive days before the beginning of the season as administered by the university's strength, and conditioning coaching staff. Informed consent was obtained from each subject in accordance with the protocol approved by the university's Institutional Review Board.

Procedures

Group assignment

Participant data were assigned into two different groups based on football position. The skill players group (SKILL) included quarterbacks, running backs, wide receivers, tight ends, defensive backs, and linebackers. The remaining non-skill players (BIG) group was comprised offensive tackles, offensive guards, defensive tackles, and defensive ends.

Anthropometrics

The details about anthropometric data acquisition and compilation have been described elsewhere.[14] Briefly, the participants were asked to fast at least 8 h before participation in the study. In a fasted state, participants had their body composition measured using a BOD POD (Cosmed, Chicago, IL, USA). BMI was determined from the quotient of weight (kg), and height (m) squared. Resting blood pressure was measured twice after participants were instructed to remain seated for 10 minutes. If values did not differ by >5 mmHg, average blood pressure of the two measures was then determined, and MAP was computed.

$$\frac{1}{3}\left(\text{SBP} - \text{DBP}\right) + \text{DBP}$$

Where, SBP and DBP indicated systolic and diastolic blood pressure, respectively. Waist circumference (WC) was measured using a Gulick II tape measure, rounded to the nearest 0.1 cm, at the high point of the iliac crest, at minimal respiration.

Performance measures

On two separate testing days, the participants were tested for one-repetition maximum bench press (BENCH), one-repetition maximum squat (SQUAT), 40-yard dash time (DASH), and vertical leap. The order of measurements tested was counterbalanced. All measurements were spotted by an athletic coach professionally trained in strength and conditioning. One-repetition maximum was defined as the maximum amount of weight the participant could lift using proper form for one repetition without receiving any assistance from a spotter. For the BENCH and SQUAT measurements, each participant performed three one-repetition trials after a warm-up period. BENCH and SQUAT were determined from the trial, in which the maximum weight was lifted in the bench press and squat exercises, respectively. DASH was timed on an artificial turf field using a standard stopwatch. Participants performed two 40-yard sprints, and the lowest time was determined to be DASH. The same individual timed all participants, and timing began when the first movement by the participant was detected. The vertical leap was determined as the best of three jump trials as measured on a Vertec Vertical Jump trainer. Participants were instructed to jump as high as possible using only a countermovement. POWER was then computed from the vertical leap and mass measurements. Players who did not have valid measurements for any of the performance measures were removed from the analysis for that measures (Table 1).

Statistical analyses

A series of univariate linear regressions was performed using SPSS (version 18.0, Chicago, IL, USA) to test the association between the performance variables (BENCH, SQUAT, DASH, and POWER) and MAP. Participants who were unable to be tested for a specific performance measure were omitted from the respective analysis. Regression analyses were run for all subjects, and subsequent analyses were run to test the association between DASH and POWER and MAP in the SKILL group only. This was done to assess the possible influence that high BMI and/or % body fat (BF) may have had on resting blood pressure in this group as non-skill players tend to have higher BMI and BF. Independent *t*-tests were run to establish the difference in body composition between SKILL and BIG groups. Statistical significance was established a before test the hypothesis that participants would exhibit higher resting blood pressure with increasing muscular power capacity.

Results

Table 2 displays anthropometric data for SKILL and BIG. Mass, BMI, BF, and WC were all significantly different between SKILL and BIG groups ($P \leq 0.001$) (Table 2). Linear regression detected significant, positive relationships between BENCH and MAP ($r = 0.314$; $P = 0.010$), POWER (all players) and MAP ($r = 0.269$; $P = 0.035$), and POWER (SKILL only) and MAP ($r = 0.427$; $P = 0.004$) (Table 1). Figures 1 and 2 display the relationship between PI and MAP for all players and SKILL only, respectively. No definitive relationship was found to exist between SQUAT or DASH and MAP.

Table 1: Association between performance measures and resting blood pressure

Metric	*n*	*p*	*r*
BENCH	66	0.010*	0.314
SQUAT	56	0.632	
DASH	64	0.088	
PI	62	0.035*	0.269
DASH**	40	0.396	
PI**	39	0.004*	0.425

*Indicates significance (P<0.05). **Indicates SKILL group analysis only. PI: Power index

Table 2: Body composition measures for skill (SKILL) and non-skill (BIG) players

Group	*n*	Mean±SD			
		Mass (kg)	BMI (kg* [m²])⁻¹	BF (%)	WC (cm)
SKILL	56	90.6±9.2	26.9±2.5	12.6±4.8	84.7±5.6
BIG	24	119.7±12.1	32.6±2.9	22.0±4.1	100.0±6.6

SD: Standard deviation, BMI: Body mass index, BF: Body fat, SD: Standard deviation, WC: Waist circumference

Discussion

The purpose of this study was to assess the effect of muscle fiber type distribution on resting blood pressure in collegiate-level football players by utilizing muscular power capacity as a proxy for fiber type distribution. The tested hypothesis was supported by the existence of a significant, positive relationship between muscular power and MAP as observed in this study (Table 1), suggesting that a link exists between an individual's muscle fiber type distribution and resting blood pressure. Because of the association between hypertension and fast twitch (FT) muscle fibers, more accurate determination of this relationship may be helpful in demonstrating an individual's current or future risk for cardiovascular disease.

This study's findings support previous research that has indicated a link between fiber type distribution and the

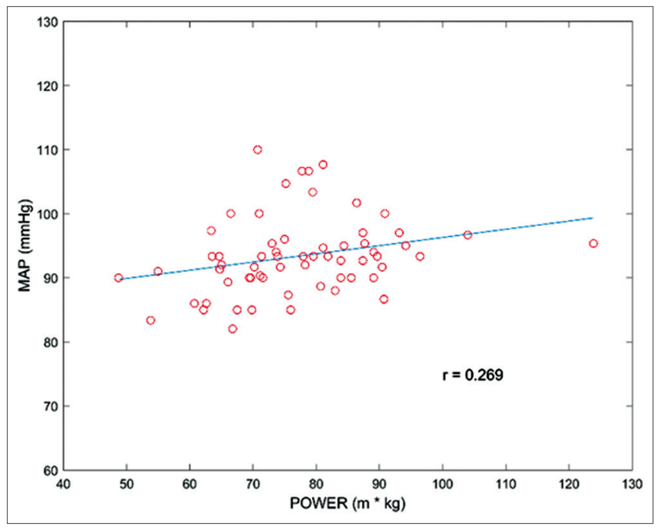

Figure 1: Relationship between power index and resting blood pressure in collegiate football athletes

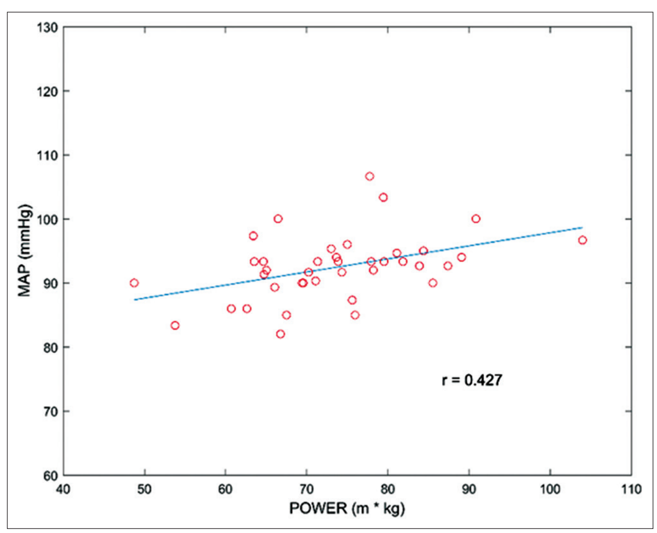

Figure 2: Relationship between power index and resting blood pressure in collegiate football athletes in skill players only

development of hypertension.[9,10] Arterial blood pressure has been found to be inversely related with the percentage of ST fibers in normo- and hyper-tensive individuals,[10] and similarly, hypertensive patients were found to possess significantly higher percentages of FT fibers compared to their normotensive age- and sex-matched peers.[9] Assessment of an individual's fiber type distribution may help clarify the presence of elevated blood pressure. In lieu of direct muscle biopsy, an assessment of muscular power may serve as an effective proxy for muscle fiber type distribution. Vertical leap, used and reported in this study as PI, is an explosive movement that is a direct assessment of muscular power and may be used as a reliable indicator of an individual's muscle fiber type distribution. Power lifters, for whom muscle biopsy of the vastus lateralis showed a significantly higher percentage of Type IIa muscle fibers, were found to be able to leap significantly higher than controls.[13] Given that muscular power capacity, evidenced by PI, is an accurate evaluation of muscle fiber type distribution, the results of the present study indicate that there may be a fundamental link between fiber type and its effects on resting blood pressure.

Although the relationship between muscle fiber type distribution and resting blood pressure is evident, it is generally unclear as to why this relationship exists. There is evidence that specific physiological mechanisms—namely higher incidence of anaerobic metabolism[15] and resting lactate levels[16]—that indicate a higher proportion of FT muscle fibers may contribute to this association. In an early study by Demartini *et al*.,[15] hypertensive patients were found to have elevated blood lactate concentrations, which may indicate an association between resting lactate levels and elevated blood pressure. Lactate is a metabolite of glycolytic, or anaerobic, metabolism.[17] At a given exercise intensity, therefore, blood lactate concentration can be construed as a function of the glycolytic metabolism required to perform that exercise. In another early study by Stuart *et al*.,[16] elite sprinters exhibited much higher resting blood lactate concentrations than elite distance runners, suggesting that the sprinters in the study presented higher incidence of anaerobic metabolism. Considering elite-level sprinters are likely characterized by a higher percentage of FT muscle fibers, these individuals might exhibit increased anaerobic metabolism as a result of this distribution.

Football players are largely strength and power athletes and subsequently train to maximize these to effectively compete and reduce the risk of injury. Consequently, elite players, especially offensive and defensive linemen, tend to have BF and BMIs that are disproportionate to their level of fitness. Moreover, given their higher BF and BMI than players categorized as SKILL, those players categorized as BIG players may be at exceptional risk for metabolic syndrome.[6] Adults with a BMI of 25.0-29.9 are considered overweight, while those with BMI >30.0 are considered obese. Elite football players who had significantly higher BF and BMIs were found to have blood pressure in the pre-hypertensive range at the professional[3] and collegiate[2,4,18] level. Because high BMI and BF have been implicated in the development of hypertension, subjects' BF and/or BMI may have affected their resting blood pressure, regardless of position. However, the presence of elevated blood pressure with increasing muscular power capacity was preserved in the absence of excessive BF, as evidenced by the significant relationship observed between PI and MAP in the SKILL subset. Although mean BMI of the SKILL group fell into the overweight range, it was likely skewed due to increased muscle mass, as mean BF in this group was in the normal range for adult men. Previously, collegiate players categorized as SKILL players have displayed resting blood pressure in the pre-hypertensive range.

Although PI was an effective assessment of muscular power in this study, further research that more accurately assesses an individual's muscular power capacity may be of interest. An obvious limitation of the study was the absence of a direct measurement of fiber type through muscle biopsy. In addition, other factors that may predispose and individual to cardiovascular disease, such as diet, family history,[5] or ethnic background, were not taken into account. In addition, all the players in the present study were from one university. Further research that takes into account the above factors as well as assesses a broader and more diverse population of elite athletes is warranted to increase the generalizability of the study's findings.

Conclusion

Determining an individual's risk for cardiovascular disease is important at an early age. This is especially so for young athletic populations, who are often overlooked when it comes to cardiovascular disease risk. American football coaches can benefit from this insight by assessing their players' risk for cardiovascular disease, using resting blood pressure as a barometer for this risk, and, considering the potential for morbidity and mortality associated with cardiovascular disease later in adulthood, help them to manage their risk.

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