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Cardiovascular Health Risk of Collegiate Division 1 American-Style Football Athletes

Ashley Ring
a.ring1513@gmail.com

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Ashley Ring

Sophie Pomhren and Dr. Nadine Mikati

Nova Southeastern University- Dr. Kiran C. Patel College of Osteopathic Medicine

Department of Nutrition

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Abstract:

Background: Cardiovascular disease (CVD) is considered the leading cause of death around the world, with risk factors including obesity and hypertension. Collegiate American Style Football (ASF) players make up a unique subset of the population that could be at an increased risk of CVD. This cross-sectional study aims to evaluate the presence of cardiovascular risk factors in a Division 1 ASF team.

Methods: The researchers analyzed the body mass index (BMI), waist circumference (WC), systolic blood pressure (SBP), diastolic blood pressure (DBP), and body fat percentage (BF%) of the team as a whole (n=38); and then compared the data to validated cut-off measurements for obesity and hypertension. Additionally, the participants were split into linemen (n=14) and non-linemen (n=24) groups and compared using an independent t-test.

Results: The overall team analysis showed all the mean measurements fell below the validated cut-offs of 102cm, 25%, 30kg/m^2, 130mm Hg, and 80mm Hg. In the linemen group, the WC, BF%, SBP and BMI met or exceed the validated cut-offs, while the DBP was below its cut-off. In the non-linemen group, the measurements all fell below the validated cut-offs. When comparing the two groups, the WC, BF%, and BMI measurements of the linemen were significantly higher than the non-linemen ($p<0.001$ for each), while there was no significant difference between the linemen and non-linemen measurements ($p= 0.754$ and $p= 0.927$ respectively).

Conclusion: The linemen athletes had an increased risk of CVD development due to the presence of measurements indicating obesity and hypertension in this population.

Keywords: cardiovascular disease (CVD), American-style football (ASF), risk factor, hypertension, obesity, college

Introduction:

Cardiovascular diseases (CVD) are the number one cause of death throughout the world. [1] They are chronic diseases that affect the heart and circulatory system and are often caused by atherosclerosis, which is a buildup of plaque on the artery wall that restricts proper blood flow and leads to inflammation of the vessel walls.[2,3] CVD gradually develops throughout an individual's life and can be asymptomatic for much of that time. Many times, the first CVD symptoms an individual experiences are when the disease is in an advanced stage or even sudden death.[2] Risk factors for CVD include gender, genetic heritage, obesity, hyperlipidemia, and hypertension (HTN) among others.[1,2] Around three-quarters of the deaths resulting from CVD can be prevented through lifestyle changes such as consuming a healthy diet, increasing exercise, and decreasing obesity.[1, 4, 5, 6]

In the United States, American Style Football (ASF) is the most popular team sport, with ASF athletes being considered at the height of health.[7] Recently, the possible long-term health effects on these athletes, such as neurocognitive and cardiovascular health, have become topics of interest. In regard to cardiovascular health, ASF athletes have deliberate weight gain, psychosocial stress, large amounts of static hemodynamic stress, low aerobic conditioning, and routine nonsteroidal anti-inflammatory drug (NSAID) use. American style football athletes are part of a unique group within the population that could have an increased CVD risk.[8] Though cases of clinical CVD are considered rare in highly active young athletes, ASF athletes are exposed to certain CVD risk factors such as increased body size, abnormal lipoprotein levels, and high blood pressure.[9] As early as high school, ASF athletes are showing increased CVD risk factors such as dyslipidemia.[10] For example, approximately 54% of high school ASF athletes had low levels of high density lipoprotein C and 13% had elevated levels of triglycerides, which is associated with an increased risk of CVD. Additionally, throughout participation in collegiate ASF, athletes have shown significant increases in both systolic and diastolic blood pressure (BP) during their season.[11] This has been associated with maladaptive adaptations in the cardiovascular system, especially the heart.

It is commonly known that body size is very important in ASF, where the athletes work to gain body mass often through a high calorie diet.[9] On average across all positions, ASF athletes gain 40-lbs throughout and following their career, with the majority of the weight gain occurring while actively playing.[11] The weight gain seen in these athletes during their ASF career offsets the cardioprotective nature of exercise.[9, 12, 13] ASF athletes commonly are considered obese using body composition measurements such as body mass index (BMI), waist circumference (WC), and body fat percentage (BF%).[7,9] There is a greater prevalence for ASF athletes to have a BMI over 30kgm^2, a WC over 100 cm, and a BF% over 25% when compared to healthy controls as well as with other athletes.[9] While playing at a larger size is encouraged, especially amongst linemen, it has also been shown that former athletes who played with a BMI over 30, have a 50% increase in cardiovascular related deaths when compared to healthy controls.[7,14] In the US, there are around 2,000 professional football athletes and 70,000 collegiate football athletes, which emphasizes the importance of investigating the CV health of these athletes to determine their CV risk.[7] It also demonstrates the need for clinical observation while in college and a possible need for intervention.

Evaluating the prevalence of CVD risk factors is important for determining the future cardiovascular health of these athletes and potentially enable them to make changes that could prevent its development. The aim of this study is to determine if collegiate American Style Football players are at increased risk for developing cardiovascular disease by using standard validated morphological and hematological objective measurements. I hypothesize that the ASF athletes will have a higher risk of CVD and the linemen positions will have a significantly higher measurements for the CVD risk factors than the other positions.

Methods:

Study Design:

This cross-sectional study evaluated the prevalence of the CVD risk factors - hypertension and obesity - in one Division 1 collegiate ASF team by looking at blood pressure, BMI, BF%, and WC. The athletes were recruited initially using an in-person

presentation and flyer. The players interested in participating completed both informed consent and release of medical information documents. The IRB approval was through Nova Southeastern University.

Study Population:

This study included males aged 17-24 on a Division 1 Collegiate 2020 Varsity Football Team who were either actively participating on the team or were unable to participate fully due to injury or other reason. Of the possible eligible 121 team members, 44 participated. Six players were removed as they were unable to complete all the measurements, leaving the final number of study participants at 38.

Data collection:

The height and blood pressure measurements were gathered during the athlete's pre-participation physical by the athletic training staff. The university's sports medicine team collected the body fat percentage using the dual-energy x-ray absorptiometry (DXA) scanner. The WC measurements were collected using a tape measure at the level of the iliac crest by the co-investigator, Sophie Pomrehn. The weight was collected using a Gx Kinduct scale that would automatically upload to the Kinduct Athlete Management System that was accessed by Sophie Pomrehn. The weight was collected within the two weeks prior to the DXA scan completion. The BMI was calculated using the collected height and weight. The information was collected directly from the university's Sports Medicine or Nutrition systems. The data was de-identified prior to removing it from its primary location to minimize the risk of loss of confidentiality.

Statistical Analysis:

The player data was compared with the known cutoff measurements listed below. The values represent the validated cut-offs for obesity and hypertension, which are the risk factors being measured in this study. The statistical analysis was completed using IBM SPSS Statistics 26 software. The data was grouped by the team (n=38) as a whole and analyzed using descriptive statistics to evaluate the presence of CVD risk factors. Then, the data was grouped based on position, linemen (n=14) vs. non-linemen (n=24), and

an independent t-test was used to compare the positions to determine if there was a significant difference between cardiovascular health risk measurements of the position groups**.** The linemen group includes the offensive and defensive linemen, while the non-linemen group includes all other positions including quarterback, linebacker, tight end, running back, special teams, wide receiver, and defensive back.

Measurements:

- BMI $\geq$ 30 kg/m^2 considered obese[15, 16]
- WC $\geq$ 40 inches/ 102 cm corresponds to obese BMI[15, 16]
- Systolic Blood Pressure $\geq$ 130mm Hg considered hypertension[17]
- Diastolic Blood Pressure $\geq$ 80mm Hg considered hypertension[17]
- Body Fat Percentage >25% indicator of obesity[17]

Results:

The overall team measurements were averaged and compared to the validated cut-offs for obesity and hypertension (Table 1). The mean WC was 95.49 ± 9.856cm, the mean BF % was 21.72 ± 6.034%, and the mean BMI was 24.66 ± 4.503 kg/m^2. The mean systolic blood pressure (SBP) was 129.4 ± 9.318mm Hg and the mean diastolic blood pressure (DBP) was 75.08 ± 6.855mm Hg. None of the mean measurements were above the validated cut-off levels.

Measurement	Mean	Validated Cut-Offs
WC (cm)	95.49 ± 9.856	≥102
Body Fat (%)	21.72 ± 6.034	> 25
SBP (mm Hg)	129.4 ± 9.318	≥ 130
DBP (mm Hg)	75.08 ± 6.855	≥ 80
BMI (kg/m^2)	24.66 ± 4.503	≥ 30

Table 1: Average measurements of all the study participants for waist circumference (WC), body fat percentage, systolic blood pressure (SBP), diastolic blood pressure (DBP), and body mass index (BMI) along with their validated cut-off measurements for obesity and hypertension.

Table 2 shows the average measurements for the linemen (n=14) and non-linemen (n=24) groups. For the linemen group, the WC was 107.1 ± 3.886cm, the BF% was 28.11 ±4.059%, SBP was 130.0 ± 6.051 mm Hg, DBP was 75.21 ± 7.526mm Hg, and BMI was 36.15 ± 1.817kg/m^2. The WC, body fat percentage, SBP and BMI either meet or exceed the validated cut-offs of 102cm, 25%, 130mm Hg, and 30kg/m^2 respectively. The DBP was the only measurement below its cut-off of 80mm Hg. For the non-linemen group, the WC was 88.72 ± 4.224cm, the body fat percentage was 17.99 ± 3.141%, the SBP was 129.0 ± 10.89mm Hg, DBP was 75.00 ± 6.600mm Hg, and the BMI was 75.00 ± 6.600 kg/m^2. None of the mean measurements met or exceed the validated cut-offs of 102cm, 25%, 130mm Hg, 80mm Hg, and 30kg/m^2 respectively. The two groups were then compared using an independent t-test, results shown in Table 2. For the WC, body fat percentage, and BMI measurement independent t-test comparisons, the linemen were significantly higher than the non-linemen ($p<0.001$ for each). Significance is defined as $p<0.05$. When comparing the SBP and DBP there was no significant difference between the linemen and non-linemen measurements ($p= 0.754$ and $p= 0.927$ respectively). Figure 1 shows the waist circumference comparison where the linemen have significantly higher WC than the non-linemen ($p<0.001$). Figure 2 shows the body fat percentage comparison where the linemen average measurements were significantly higher than the non-linemen ($p<0.001$). Figure 3 also shows the results of the independent t-test comparing the BMI measurements of the two groups. The linemen BMI was significantly higher than the non-linemen BMI ($p<0.001$). Figure 4 shows the comparison of the SBP for both groups with no significant difference observed ($p=0.754$). Finally, Figure 5 demonstrates the comparison of the DBP between the groups where there was also no significant difference found ($p= 0.927$).

Measurement	Linemen	Non-linemen	Two-Tailed P-Value	Validated Cut-Offs
WC (cm)	107.1 ± 3.886	88.72 ± 4.224	<0.001*	≥102
Body Fat (%)	28.11 ±4.059	17.99 ± 3.141	<0.001*	> 25
SBP (mm Hg)	130.0 ± 6.051	129.0 ± 10.89	0.754	≥ 130
DBP (mm Hg)	75.21 ± 7.526	75.00 ± 6.600	0.927	≥ 80
BMI (kg/m^2)	36.15 ± 1.817	27.74 ± 1.886	<0.001*	≥ 30

Table 2: Average measurements collected for waist circumference(WC), body fat percentage, systolic blood pressure (SBP), diastolic blood pressure(DBP), and body mass index (BMI) of the linemen and non-linemen groups were compared to the validated cut-off measurements for obesity and hypertension. Measurements were compared using an independent t-test. The * indicates a significant difference between the linemen and non-linemen groups. Significance is defined as p<0.05.

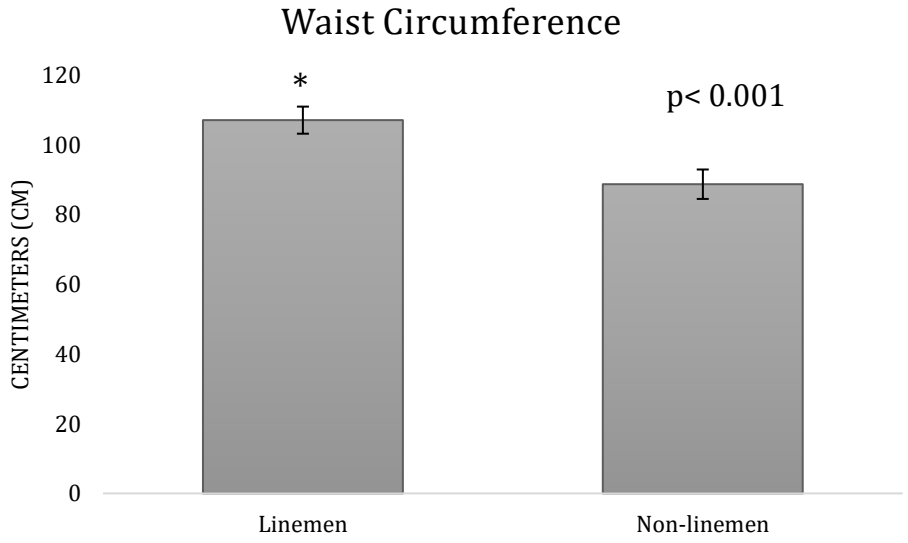

Figure 1: Waist Circumference (WC) results from the independent t-test comparing the means of the linemen and non-linemen groups. The linemen group had significantly higher WC than the non-linemen group (p<0.001*; * = significant difference). Significance is defined as p<0.05.

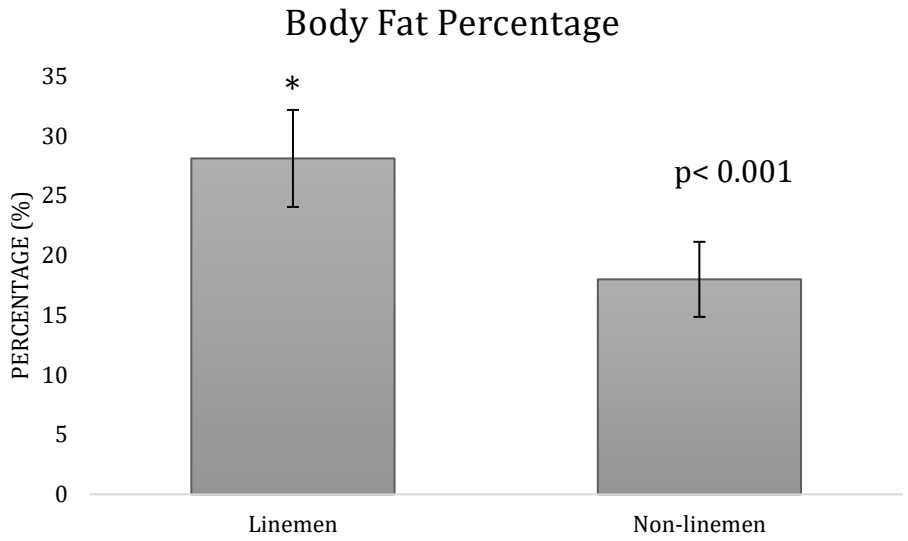

Figure 2: Body fat percentage results from the independent t-test comparing the means of the linemen and non-linemen groups. The linemen group had a significantly higher body fat percentage than the non-linemen group ($p<0.001$*; * = significant difference) Significance is defined as $p<0.05$.

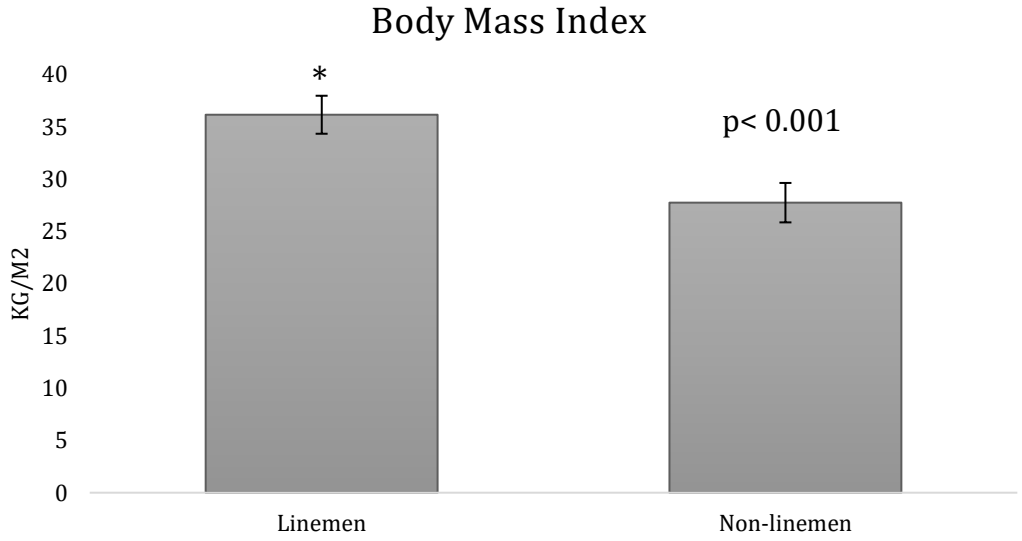

Figure 3: Body mass index (BMI) results from the independent t-test comparing the means of the linemen and non-linemen groups. The linemen group had significantly higher BMI than the non-linemen group ($p<0.001$*; * = significant difference). Significance is defined as $p<0.05$.

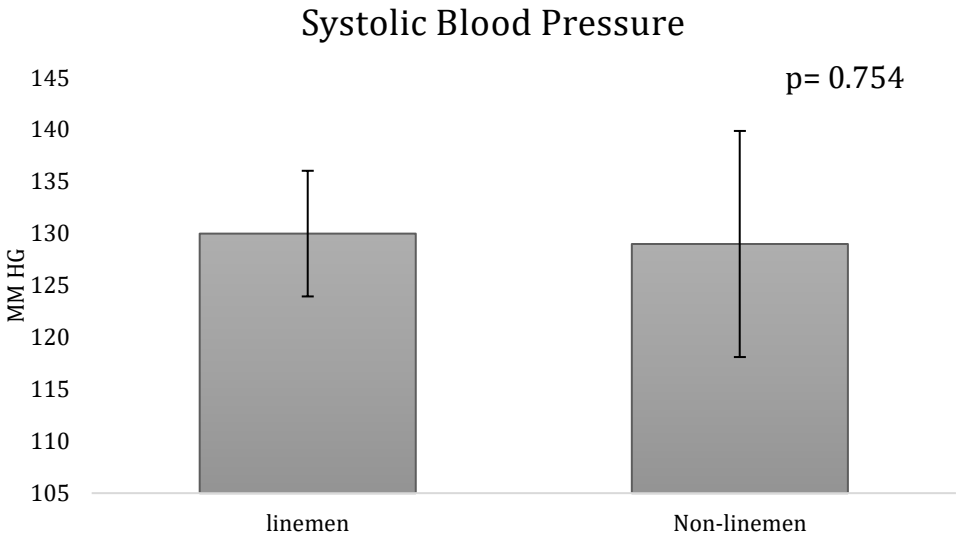

Figure 4: Systolic blood pressure (SBP) results from the independent t-test comparing the means of the linemen and non-linemen groups. There was no significant difference in SBP between the two groups (p=0.754). Significance is defined as p<0.05.

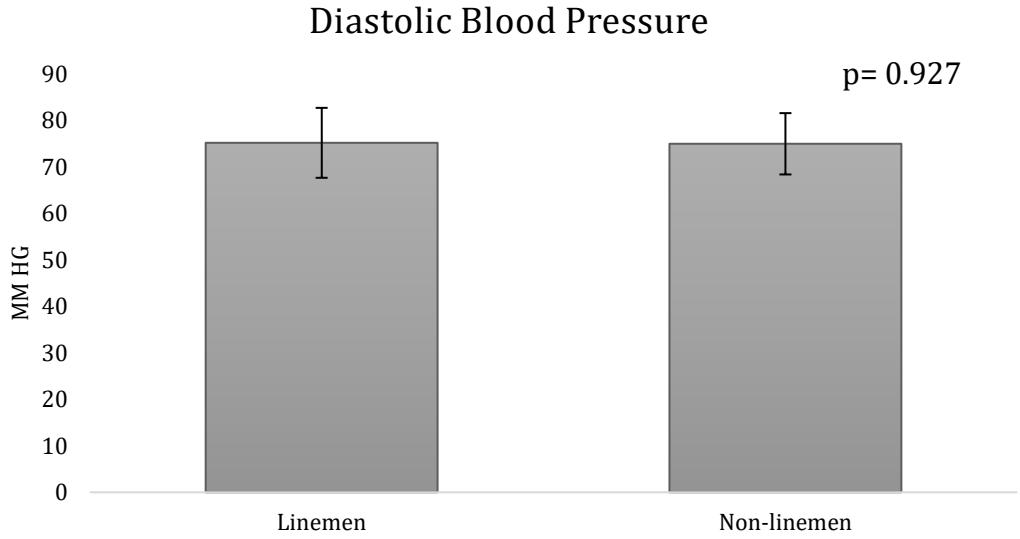

Figure 5: Diastolic blood pressure (DBP) results from the independent t-test comparing the means of the linemen and non-linemen groups. There was no significant difference in DBP between the two groups (p=0.927). Significance is defined as p<0.05.

Discussion:

Cardiovascular disease is a multifactorial disease that requires monitoring of multiple risk factors at once and is the number one cause of death around the world. [1,18] The

more risk factors present, the higher the risk of developing CVD for the individual. Much of the current research only looked at one risk factor at a time and was retrospective, looking at what risk factors were present during their careers after they have developed CVD. This study looks at multiple risk factors, obesity and hypertension, using common measurements that can be completed during the pre-participation physical. By evaluating and monitoring the CVD risk factors of the participants, education can be introduced to help the players understand their risk and identify how they can mitigate that risk moving forward so they will be able to make lifestyle changes to prevent CVD development later in life.

The three key findings of this study include: the overall team measurements all fall below the validated cut-offs for hypertension and obesity; the linemen group met or exceeded the cutoffs in all but the DBP measurement, while the non-linemen group fell below the cut-offs in all measurements; and finally, when comparing the two groups, the linemen group had significantly higher measurements in three of the five measured points. In looking at the team results, the ratio of positions in the study population (with 24 non-linemen and only 14 linemen participants), which is consistent with the ratio of positions generally seen on a football team, shifted the results to averages below the validated cut-off measurements. This can be seen as the BMI, WC, and BF% were all significantly higher in the linemen when comparing the two groups, which is consistent with other studies.[7,19] Considering the majority of the study population had a significantly lower body size, it would be consistent that body composition measurements would average out to be a measure below the cut-offs for obesity.

Body mass index is most commonly used to classify obesity, in athletes, especially larger muscular athletes, however, this measurement may overestimate their body fat.[7,20,21,22] Chang *et al.*[21] even notes that because the BMI is not fully accurate for athletes, it is unknown if the association of a higher BMI with a higher CVD risk is relevant in this population.[21] At the same time, other studies have shown a direct link between cardiovascular health and body composition in this population.[19] Though BMI

may not demonstrate the fat distribution in the body, it is strongly correlated to fat mass increase.[22]

Waist circumference and BF% (especially from a DXA scan) can give a better look at the distribution of fat throughout an athlete's body, which is why they were included along with the BMI to determine the athletes' accurate body composition.[7,8] Wilkerson *et al*.[23] demonstrated WC, compared to both BF% and BMI, was better at determining health risks associated with obesity.[23] Abdominal or central adiposity, is known to be associated with a high CVD risk and decreasing abdominal adiposity could prevent and even stop the progression of disease.[19] Additionally, early-life weight gain, particularly as players transition from high school to the collegiate level, has been shown to be a novel risk factor of CVD.[12,24] In ASF athletes where body size matters, it would be unrealistic to ask them to lose substantial weight during their playing career especially as a linemen.[17] Instead these players may need increased education in both heart health and nutrition in order to decrease the risk of CVD development after they have finished training. Carroll and Dudfield[25] determined that visceral fat can be decreased by 2-5% for every kilogram body weight that is lost.[25] Making these kinds of lifestyle changes following their career could help decrease the likelihood of ASF athletes developing CVD later on in life.

Hypertension is another CVD risk factor that has been shown to be present in ASF athletes.[7] Though the majority of the BP measurements, both in the team as a whole and in the position groups, were not considered to be hypertensive blood pressures, they were still considered to be an elevated blood pressure (120-129mm Hg SBP). The linemen group was the only group considered to have a hypertensive SBP. The results are consistent with multiple current studies demonstrating an established link between incident hypertension and ASF participation, especially in linemen, which could be due to their increased size.[7,11,26] McCarthy and Web[11] posited the increased levels of visceral adiposity and body weight, especially seen in linemen, makes up 65-78% of the risk of hypertension.[11]

Blood pressure is not a static measurement and changes over time even within a season. Kim *et al.*[7] found freshman collegiate players had a significant increase in both SBP and DBP during their first season. Interestingly, McCarthy and Webb[11] noted that the hypertensive and prehypertensive incidence seen in a season does not significantly change throughout the four years of collegiate football participation.[11,27] They mentioned it was possible the players' BP could normalize in the off season and increase during season meaning the increases in blood pressure during season may not have a cumulative effect on the players overall hypertension incidence. The BP data from this current study was collected at a single point in time at the beginning of a season so it did not take into account the possibility of changes in SBP and DBP throughout a season.

Limitations:

Limitations of this study include the length of time between the collection of the various measurements. Due to the restrictions from the COVID-19 pandemic, the DXA scan was unable to be collected at the beginning of the season, which is the normal protocol. As a result, the BF%, WC, and weight were collected nearly six months after the BP and height. Considering BP is known to change during a season, this could lead to changes in risk factor presentation. Ideally, all the information would be collected within one to two weeks of each other during the pre-participation physicals to ensure the information accurately depicts the athletes' risk factors at the given time of the measurements. Another limitation is the unknown effect of the COVID-19 pandemic on long-term cardiovascular health. It is known some of the players on the team did contract COVID-19 but in this study, it is unknown which or if any of the participants had COVID-19 and how it could have affected their measurements. Studies have shown in both athletes and nonathletes that cardiac injury can occur as a result of SARS-CoV-2 infection, however, there is currently no longitudinal data on how it could affect CVD development later in life as it is a new and evolving issue.[28,29,30,31] Until this information is known, it would be important for players who do contract COVID-19 to follow the return to play recommendations which includes monitoring and testing to ensure athletes are safe to resume practice and competition.

Future Directions:

Further research could include collecting data at one data point, as was the original intent of this study, to see if the results remain consistent. Researchers could also utilize multiple university football teams and additional risk factors such as blood lipid levels to determine if the results follow the current trend and could be generalizable. Another study could be a longitudinal study that follows ASF athletes from their freshman year in college, into their professional career (if they continue to play), and beyond into their life following their ASF career. This would enable researchers to follow the development of risk factors as well as the possible development of CVD. Finally, since education interventions have been suggested in this study and others, it would be interesting to analyze the effectiveness of different types of education interventions to determine which would be best at not only increasing the players understanding of CVD and what their health is in regard to risk, but also in its ability to lead to lifestyle changes during and following playing to potentially prevent the development of CVD.

Conclusion:

Overall, while the team as whole did not currently present an increased risk for CVD, the linemen were shown to have an increased CVD risk due to the presence of measurements classified for hypertension and obesity. Additionally, the linemen are more likely to develop CVD than non-linemen based on the current presence of risk factors. The information gained from this study could be used to improve the pre-participation physical for the ASF athletes to include risk factors for CVD development. This would enable them to identify risk factors any athlete is exhibiting in order to better manage them. Additionally, this would allow the sport medicine teams to provide education on CVD and the measures they can take moving forward in their life and playing career to minimize their risk of developing CVD.

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