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A Heartbreaking Loss: An Analysis of the Long-Term Negative Cardiometabolic Effects of Unhealthy Bulking Practices in American Football Players

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Abstract

A Heartbreaking Loss: An Analysis of the Long-Term Negative Cardiometabolic Effects of Unhealthy Bulking Practices in American Football Players

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National Football League records have shown a marked increase in the average weight of American Football Players over the course of the past half century. The emphasis placed on the ideology that "bigger is better" may enable these athletes to perform at higher levels of competition; there is now however an increased concern for the cardiometabolic health of these athletes due to the accumulation of fat mass rather than muscle mass. Numerous studies have proven a correlation between a high quantity of fat mass and the onset of cardiometabolic disorders such as diabetes mellitus, high blood pressure, and coronary artery disease. Additionally, analysis of present-day National Football League draft informatics indicates that many current professional American football players fit within the Body Mass Index classifications of overweight or obese (levels I, II, or II). In the general population, body mass index classification has been shown to be a strong indicator of an individual's likelihood to develop cardiovascular disease. In athletic populations, body mass index may not accurately represent the overall health of the individual due to an inability to discriminate between muscle and fat mass. However, in larger athletes such as offensive and defensive linemen, subjects are large enough that it can be assumed that they are holding a moderate to high level of body fat-specifically visceral fat. Visceral fat being another major indicator of an individual's likelihood of developing cardiometabolic disease. Researchers have found that in American collegiate football players, 19.2% were hypertensive, and 61.9% were pre-hypertensive[15]. Race also represents a large risk factor for the development of cardiometabolic disease, with nonwhite persons being at greater risk. Considering the general racial demographics of American football, body mass index rating may not accurately represent the individual risk for the development of cardiometabolic disease and associated risk factors. The purpose of this analysis is to quantify the degree to which American football players at the collegiate and professional levels may be putting their long-term health at risk through the utilization of improper bulking techniques.

Keywords and Phrases: Athlete Health, American Football, BMI, Bulking, Cardiometabolic Health

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Acknowledgements

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Lastly, thank you to Eastern Kentucky University for an amazing four years; to my old Kentucky home, goodnight.

Introduction

National Football League records have shown a marked increase in the average weight of American Football Players over the course of the past half century[1]. The emphasis placed on the ideology that "bigger is better" may enable these athletes to perform at higher levels of competition; there is now however an increased concern for the cardiometabolic health of these athletes due to the creation and utilization of unhealthy bulking practices. Bulking is the process through which an athlete is pressured by personal or societal forces to gain enough weight that in a healthy adult male the maximum percent body fat is between 15-16%[8] to maintain health. Obesity is classified as a body fat percentage of 25% or greater in men; it is at this point that both athletes and non-athletes are at greater risk for developing indicators of cardiometabolic disease as well as a decrease dexterity and overall ability to perform in sport or complete activities of daily living. Athletes who do not have access to professional dieticians and strength training staff often choose to gain weight by eating massive amounts of food or by eating calorically dense foods such as fast foods. These choices are effective in aiding the athlete in gaining weight, but the weight gained is often the result of an accumulation of fat mass rather than muscle mass[9].

Numerous studies have proven a correlation between a high quantity of fat mass and the onset of cardiometabolic disorders such as diabetes mellitus, high blood pressure, and coronary artery disease[2]. Additionally, analysis of present-day National Football League draft informatics 1 indicates that many current professional American football players fit within the Body Mass Index classifications of overweight or obese (levels I, II, or III). In the general population, body mass index classification has been shown to be a strong indicator of an individual's likelihood to develop cardiovascular disease[2,3]. In most

athletes, body mass index does not accurately represent the overall health of the individual due to the systems failure to discriminate between muscle and fat mass. However, in larger athletes such as offensive and defensive linemen, athletes are large enough that it can be assumed that they are holding a moderate to high level of body fat-specifically visceral fat. Visceral fat being another major indicator of an individual's likelihood of developing cardiometabolic disease. The purpose of this analysis is to quantify the degree to which American football players at the collegiate and professional levels may be putting their long-term health at risk through the utilization of improper bulking techniques.

Literature

Obesity is defined as having a body mass index classification of 30.0 or higher. This is calculated using the formula: body mass (in kilograms) divided by height (in meters) to the 2.5^{th} power ($kg/m^{2.5}$). In a study conducted between January 2011 and December 2013 at the Bahawal Victoria Hospital in Punjab, participants (all consenting patients over the age of 18, with the exception of those who had experienced a myocardial infarction within three months of the commencement of the study, or had a history of stroke, renal failure, or congestive heart failure) were analyzed for their inherent cardiovascular health problems in relation to their BMI classifications. Patient height and weight information was collected, and BMI classifications were configured, allowing researchers to classify participants as "healthy", "overweight", or "obese". It was found that those within the "normal" category were 25% less likely to develop coronary heart disease, while those patients with diabetes mellitus and hypertensive were 71.5% and 72% respectively, more likely to fall within the obese or overweight categories-citing the

World Health Organization estimation that more than 1 billion people worldwide are overweight.[18]

In a consequent India-based study, researchers aimed to calculate and quantify whether there is a quantifiable difference in the cardiac outputs and peripheral blood flow levels of students who were obese versus those who were within a non-obese category.[19] Male students between the ages of 17 and 25 were asked to participate, however those admitting to being smokers, alcoholics, diabetics, or having diagnosed hypertension were excluded from the study. Subjects were measured for height and weight data, and scientists were then able to use Quintlet's Formula (body weight (kg)/height $(m)^{2.5}$) to calculate and classify the BMI's of each participant. Three categories were utilized: non-obese, overweight, and obese. Researchers used NIVOMON to observe the peripheral blood flow in both the right and left forearms and calves of each participant, creating an impedance plethysmograph. Results confirmed that there was indeed an overall increased cardiac output in the obese group when compared to the non-obese and overweight categories, and the mean blood flow in the dominant forearm of the obese population was significantly less than that of those within the non-obese and overweight participants. Researchers tied in previous studies which found that free fatty mass is more prevalent in determining the risk for cardiac strain or obesity-related disease in those who are classified as obese or overweight.

Researchers at Grand Valley State University challenged the adage that "bigger is better" in American collegiate football players. Professor of exercise science Jeffrey Potteiger and senior student Maggie McGowan-Stinski designed a study which analyzed the gross change in the overall size of American football players over the past seven decades.

Researchers focused specifically on offensive and defensive linemen, who are generally the largest players both in height and weight. Through analysis of height and weight records of collegiate linemen from 1942 through 2016, they found that there was a roughly sixty-pound increase in the average body mass, which equates to an increase of roughly 1.25 pounds per year[4]. Researchers concluded their discussion of results with an explanation of the cardiometabolic risks that obese and overweight (specifically players with high body fat percentages and high amounts of abdominal fat) players may face without intervention[10].

This study recognizes that lifting weights and eating massive quantities of food are not the only methodologies football players are utilizing to gain weight. There has been a massive increase in the availability and use of anabolic steroids, or human growth hormone (HGH) within the last century[11]. Athletes at both the collegiate and professional level are regularly tested via urine or blood samples by their associated governing bodies (NCAA, NFL), however it is neither impossible nor uncommon practice to manipulate the results of these tests. Athletes have been known to catheterize themselves and fill their bladders with "clean" urine, and some coaching staff may warn athletes that a representative is dropping by for a "random" test so that their athletes are able to clear their system before the test date. These methodologies carry their own risk factors for hormone and cardiovascular disease, in addition to the risk factors for cardiometabolic disease associated with large quantities of visceral fat mass.

In relation to this study of the cardiovascular risks that collegiate and professional American football players face, this study very clearly mirrors my own hypothesis that indeed bigger is not better. This study has clearly shown a marked increase in the overall

size of American football players, and supports my claim that players are being asked or forced to put their cardiovascular health at risk in order to become better competitors for the duration of their athletic careers. Additionally, by showing that there has been an increase in the gross size of American football offensive and defensive linemen, there becomes an apparent "double-edged sword"; players are putting themselves at a greater risk for impact injuries such as concussions, spinal injuries, and broken bones by facing larger opponents, but by being larger themselves they are better protected against hits from players of equal or greater size.

Researchers working in collaboration with the Journal of Sports Sciences collected morphology data within the four major professional sports divisions in the United States: Major League Baseball, National Hockey League, National Basketball Association, and National Football League to assess morphology trends in a variety of high-earning professional sports[17]. For the purpose of this thesis, data referenced is focused on the morphological changes monitored within the NFL. Researchers collected height, weight, and BMI data over 3 thirty-year periods to assess the overall changes in the size of professional football athletes in America. The first period was 1920-1950, the second was 1950-1980, and the third was 1980-2011. It was found that there was an increase of 24.8kg and 8.2 total centimeters since 1920, along with an increase of 4.5 kg per m^2 (BMI). It was also seen that during the first 30-year observation window, the masses of football athletes were normally distributed, it was not until the 1950-1980 period that peaks arose when charting player masses. Following statistical analysis, it was also determined that there were statistically significant increases in the height, weight, and

body mass indexes of professional American athletes within each of the four major divisions when monitored over three 30-year observational periods.

A study conducted by members of Harvard University's Law and Ethics Initiative of The Football Players Health Study at Harvard University, establishes the "stakeholders" (team owners, coaches, other players, team physicians, officials, the media, league business partners, and agents to name a few) who can and may influence the health of an individual player during his time as a professional football player within the National Football League and the obligations of these stakeholders to protect and promote the health of said player[5]; unfortunately it was found that these stakeholders do not uphold this responsibility for athlete health. Additionally, this study evaluates the effectiveness of current NFL health initiatives and protocols and recommends amendments to these protocols which could further protect the health of athletes within the NFL. This study found that professional players often underreport their injuries and medical conditions for fear that they will be removed from play. It also found that players are often left uninformed to some degree about their health due to pressures placed upon medical staff and the players themselves to remain in playing shape. Additionally, nearly no professional football players have experience within the healthcare field, meaning that they may not understand the long-term risks of their decisions to withhold information regarding injury and illness. The study also found that the varying roles of "club doctors", referred to here as team physicians, are often conflicting. For example, it is the job of the team physicians to help players return to play as quickly and safely as possible, but there may be cases in which a player is pressured to return to play sooner than recommended because he is at risk of losing his contract if he does not play. Situations as

such create legal and ethical conflicts which further put at risk the health of professional football players and does not breed an environment in which players can fully trust medical staff, as they are essentially asked to choose between their physical well-being and the financial stability of themselves and their families.

Unfortunately, this article does not outright support or disprove the hypothesis that American football players are at a greater risk of cardiometabolic diseases due to their high body mass index rankings. However, the basis of study does provide information regarding the failures of the healthcare system surrounding these athletes at the professional level, and reiterates that there is a greater shared responsibility of all "stakeholders" to care more for the health of the athletes rather than the potential to utilize athletes as financial tools. Harvard researchers ascertained that players are likely underreporting symptoms of cardiometabolic illnesses, that the medical staff aiding professional players may not be doing everything within their power to return players to full health following an illness or injury, and additionally that they may not be doing enough to educate players on how to remain healthy

Researchers at Ohio State University used the Functional Movement Screen to analyze the risk for lower-extremity injury in freshman football players at an NCAA Division I university[12]. Researchers analyzed the BMI and body fat percentages (via D-XA) to establish comparisons among FMS scores. It was established that those players scoring below 14 out of 21 possible points on the FMS were at a greater risk for injury, however, this is one of few studies focusing specifically on football linemen-the largest players in the sport. It was discovered that there is a correlation between lower FMS scores and players who were classified as obese, and that this correlation was overall weaker than

the correlation between low FMS scores and high body fat percentages in the studied group. It was indicated that obese linemen are at a greater risk for lower extremity injuries due in part to their body fat or due to their inability to perform with adequate and safe technique due to their overall size and relative body fat percentages (Nicolozakes, et al.).

In a study conducted by the International Journal of Vascular Medicine in 2016, football players from Ursinus College (a Division III program) were tested both before and immediately after their competitive 2015 season for the purpose of comparison to their non-athlete peers[14]. Measurements gathered included blood pressure, glucose levels, cholesterol levels, body composition, VO2 (oxygen consumption), and brachial artery diameter measurements. The measurements gathered from the athlete group were then compared to the same measures collected from two non-athlete male groups, which were striated by age and amount of exercise conducted per week. In total, 23 athletes were studied, and 19 "control" subjects were used as comparison measures. Following statistical analysis, it was found that the division III football athletes had a higher percentage of body fat, higher systolic blood pressure levels, lower VO2 max levels, and thicker carotid artery intima-media thickness (IMT) in comparison to non-athlete, but physically active males of comparable age. Additionally, when comparing the athletes by position group, it was clear that the linemen were heavier, and less physically fit than their non-lineman teammates.

The results of the study at Ursinus is mirrored by the results of a 2013 study conducted by researcher Ashley Karpinos, which was designed to determine the prevalence of cardiovascular risk factors in collegiate football players at the Division I level.

Researchers found that in American collegiate football players, 19.2% were hypertensive, and 61.9% were pre-hypertensive[15]. These studies also support the findings of Rory Weiner, who in 2013 established a study tracking the status of player blood pressure measurements throughout a single collegiate football season. Results of this study show an overall increase in blood pressure measurements in collegiate football players (DI)-roughly 120 athletes per active roster over the course of a single season.[16]

Journalist Greg Bishop tackles the perceived issue via an op-ed piece focusing on the individual experience of Redskin's player Jordan Reed[6]. He goes on to explain that the workout inducing Reed's stomach-churning results was designed by Manning Sumner, professional trainer (referred to as "professional torture of the stars") in Miami. Reed was at this time 6'4" and weighing roughly 240 pounds, meaning that under traditional BMI standards he is overweight, bordering on obese. However, despite his impending "obesity", Reed is able to "[move] faster than some wide-outs…and [push] around 500-pound sleds like shopping carts." Additionally, by 2007, Reed had collected 200 NFL receptions more quickly than any of his professional predecessors. Unfortunately, despite his uncanny athletic abilities, his size had put him at greater risk for collision, as his mass enables him to generate more momentum than his opponents and has fallen prey to (at least) five reported concussions during his career. Sumner testifies that Reed is the embodiment of what American football players are morphing into on a wide scale-large, lean, and dangerously fast. Also interviewed for the piece was Dr. James Andrews, an expert in sports medicine with a specialty in orthopedic surgery. Dr. James has been able to observe the evolution of football players over the course of his career, citing a 1959 roster from Louisiana State University (his alma mater) which listed their heaviest player

as only 207 pounds. LSU's heaviest player in 2017 was freshman tackle Tyler Shelvin, weighing 380 pounds-nearly twice the weight of the aforementioned alumnus. There can be seen an increase in the quantity of athletes functioning at heights and weights which were previously anomalous. Bigger, stronger, faster are the new norm-but with this increase there comes a greater inherent risk for injury due to the physics of the game. The larger the player, the more momentum he collects as he runs. This is exacerbated by the increased demand for speed in current football players at all levels. This combination of increased mass and increased speed (Newton's second law of motion: Force= Mass x Acceleration) leads to an increase in the gross force acting upon two players when they collide-and collisions are no rare occurrence in football. Dr. Andrews claims that he worries not just for Reed, but for all athletes under his care, "Bunch of injuries, they're just so damn big...I'm sick of seeing these guys get hurt, too."

Reed outlines his athletic career as a cycle: the more he played (and at varying positions), the more valuable he became as an athlete, and the more injuries he encountered. With inflamed joints, a broken foot, multiple recorded concussions-and likely several unreported, injuries to both ankles, unspecified injury to his right knee, the dislocation of his left shoulder, and injuries to both hamstrings, Reed's success has obviously come at a cost. However, Reed claims that by continuing to play through his laundry list of a medical history, he is securing the financial safety of his family. Reed is just one of many players who feel that their own physical and perhaps emotional wellbeing rates second to the financial security which comes from refusing to retire, in addition to the allure of being a player which fans, family, and team management can be proud of.

Sports journalist Laura Beil's article[7] is not a traditional scientific case study, however it provides additional primary-source testimony regarding the prevalence of unhealthy bulking practices in high-school aged American football players. These young men can be equally as large as their collegiate and professional counterparts, but as I mentioned previously, without access to professional dieticians and supervision from trained strength coaching staff, these young athletes are left with few to no healthy or financially realistic bulking options. The important testimony comes from current high school football coach John Jones, who was 240 pounds at the beginning of his freshman season of high school football and graduated in 2007 weighing nearly 330 pounds at 18 years old. Jones was by all accounts a successful player, leading his high school team to a state championship and eventually being recruited by Baylor University to play collegiately; Jones admitted that by his own standards, he did not utilize healthy bulking practices in his early career. Jones claims that he put on weight by eating hot Cheetos and Quarter Pounders from McDonald's-meaning that his diet was based maintaining a caloric surplus with no focus on genuine nutrition. Jones states that a turning point in his health was when a college coach approached him about the increased health risks he faced as an obese man of color: diabetes and coronary artery disease. Jones was a lineman, whose job it was to form a wall to protect the quarter back, and certainly at 330 pounds and a height of 6 feet 4 inches he would've been quite adept at such a job. However, the long-term ramifications of eating what he believes to be 5,000 calories a day to gain and retain his maximum weight have left him and his position teammates in limbo health-wise; where their size was effective for sport performance, they have now retired-without the physical stresses of competition and training they are now at greater risk to develop obesity related

diseases. One of the greatest risk factors for cardiometabolic disease is an excess of visceral (abdominal) fat, regardless of how active or muscular these players are or were, their sheer mass indicated that they are still carrying an above-average quantity of visceral fat (generally qualified as more than 25% body fat in males)[8].

Biel's use of Jones[7] as a witness to the prevalence of unhealthy bulking practices provides context to how young football players can fall into unhealthy habits to become as large as their older, wiser, and more financially free professional counterparts. It is a long process by which any human body is able to both accumulate and retain an unnaturally high amount of body mass-the question is whether or not it can be done with their long-term health in mind, or with the end goal of just being a successful athlete for a finite career period. Even for those athletes fortunate and talented enough to advance through the ranks of professional sport, there is an eventual retirement. Once a career ends, athletes are left "bulked", but without exposure to the physical stressors which may have kept their cardiometabolic health in check. Additionally, should an athlete not re-regulate his eating style and habits post-sport, he will continue to eat in a caloric excess, adding more visceral and subcutaneous fat to an already large body.

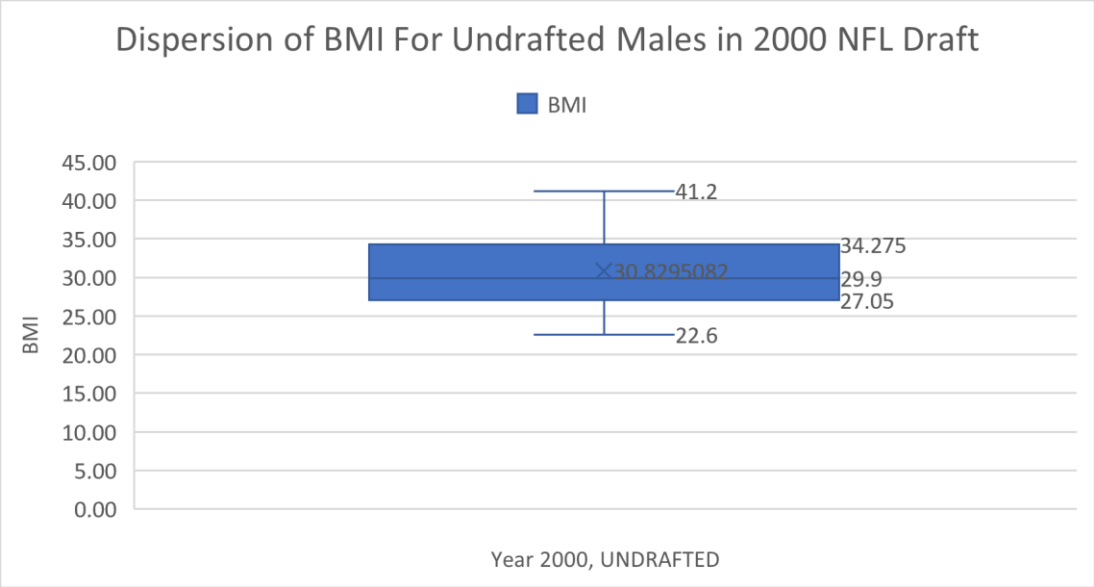
Former Denver Bronco Nate Jackson published an inside view of the National Football League's unwillingness to legitimately care for the athletes it employs[13]. Opening with the examples of Dave Duerson (who committed suicide after being diagnosed with dementia pugilistica which was linked to his history of concussions) and Kevin Everett (suffered a severe spinal injury in 2007 as a result of being hit in a "wedge" kickoff formation), Jackson's editorial piece does not shy away from the grotesque consequences of full-contact American football. Citing the Alzheimer's Association International

Convention of 2011, which found evidence that retired NFL players were at an increased risk of developing cognitive impairments which may devolve into more serious health conditions such as dementia or Alzheimer's, Jackson slams the league:

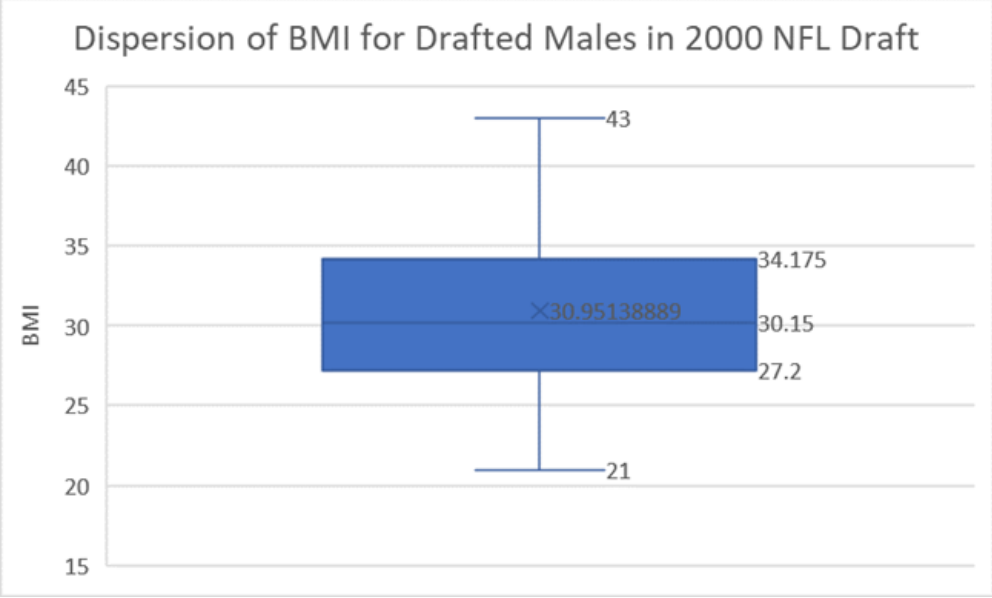
"[players] are forgotten on purpose, because acknowledging the health issues of former players draws attention to a dirty little secret: when you sacrifice your body for the game, your mind goes with it…..the train keeps moving along, pausing only to refuel with new talent and lose the dead weight of broken bodies."[13]

Original Data

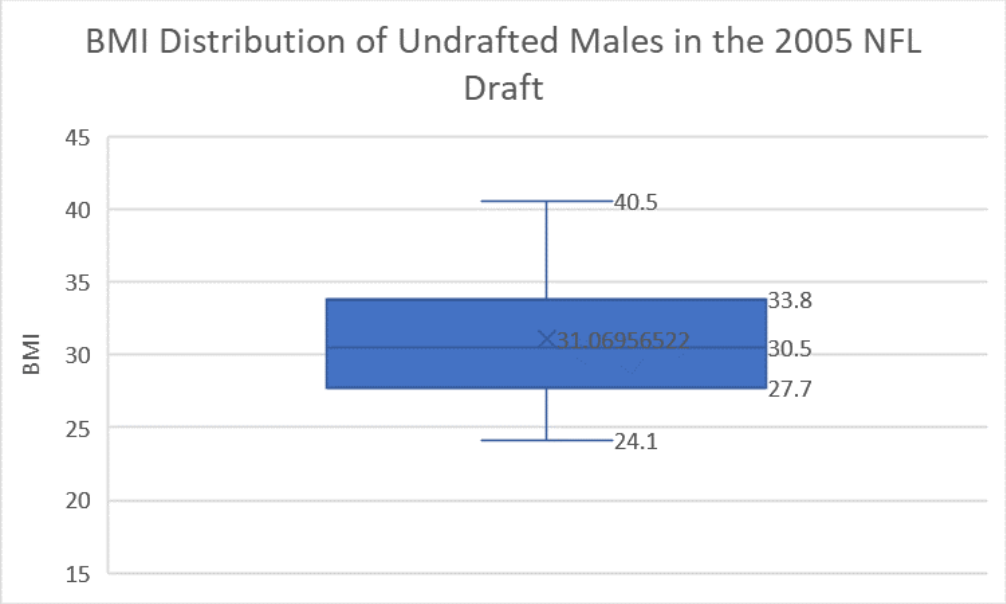
It is the goal of this study to thoroughly review previously conducted academic studies, personal testimonies of former football players, and existing National Football League draft records; from this review will stem supporting information pertaining to my argument that football players are forcing unnecessary weight and concurrent long-term negative health effects upon themselves in the name of heightened performance. It can be seen in the previous section how the synthesis of information from printed sources will be utilized within my own argument. The statistical analysis of NFL draft records will be conducted using computer software, as seen below:



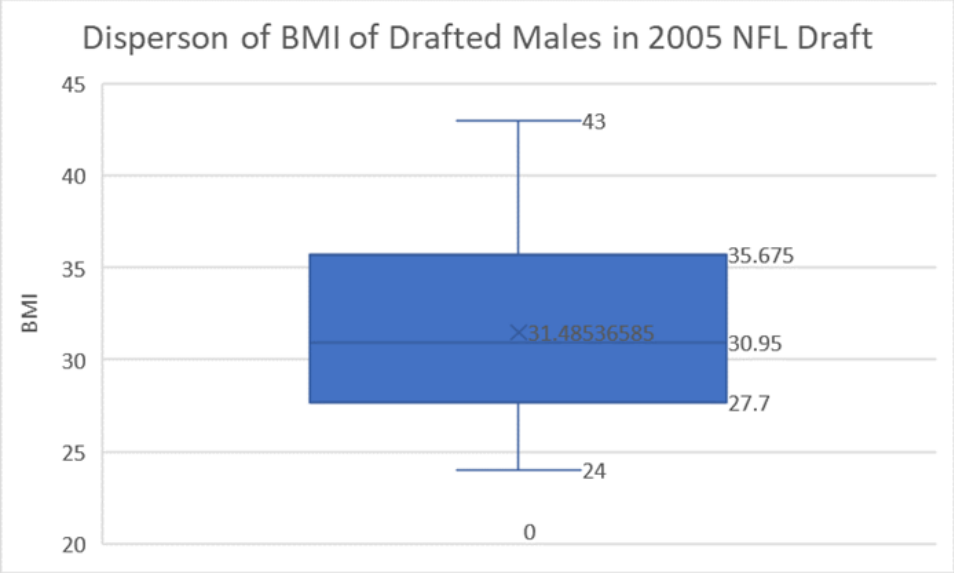
Dispersion of BMI for Undrafted Males in 2000 NFL Draft



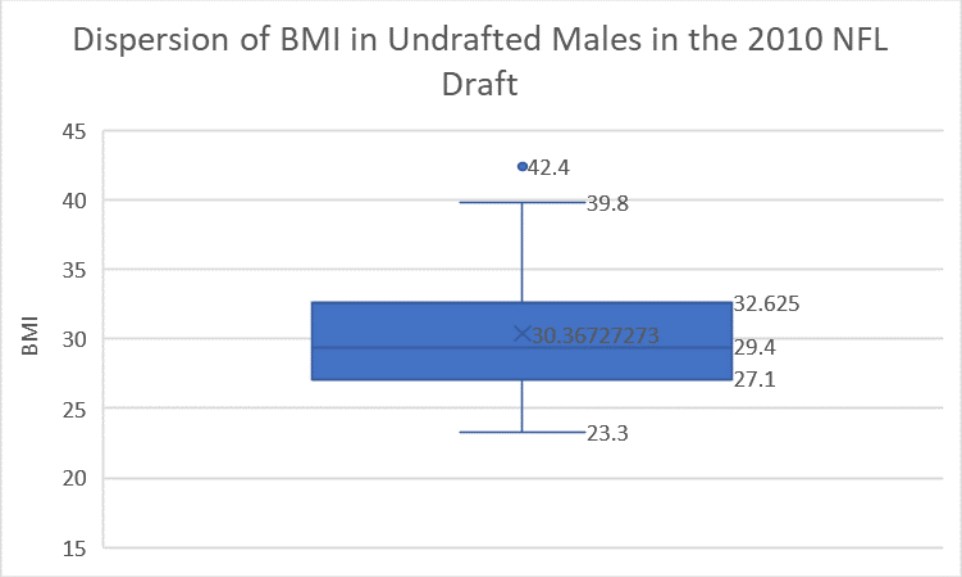
Dispersion of BMI for Drafted Males in 2000 NFL Draft



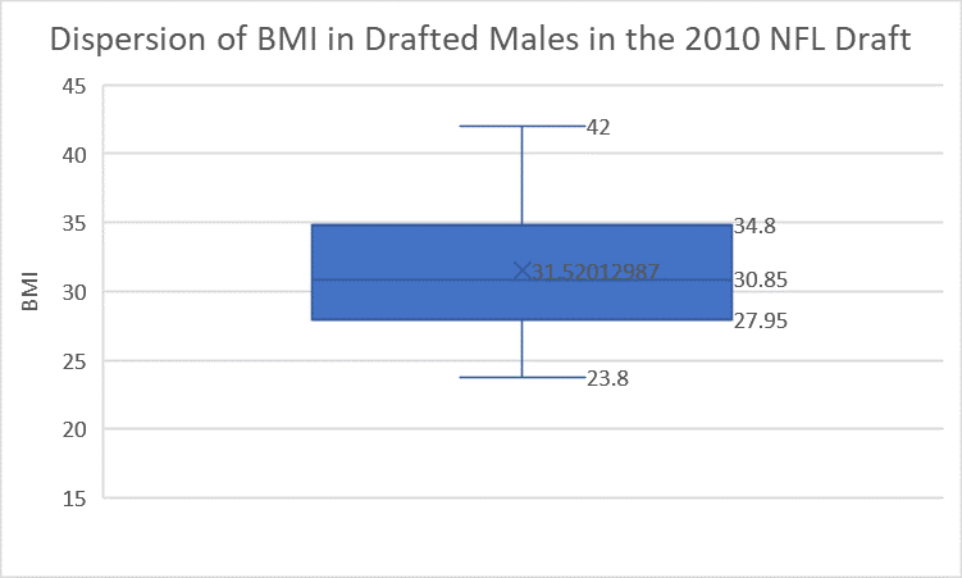
BMI Distribution of Undrafted Males in the 2005 NFL Draft



Dispersion of BMI of Drafted Males in the 2005 NFL Draft



Dispersion of BMI in Undrafted Males in the 2010 NFL Draft



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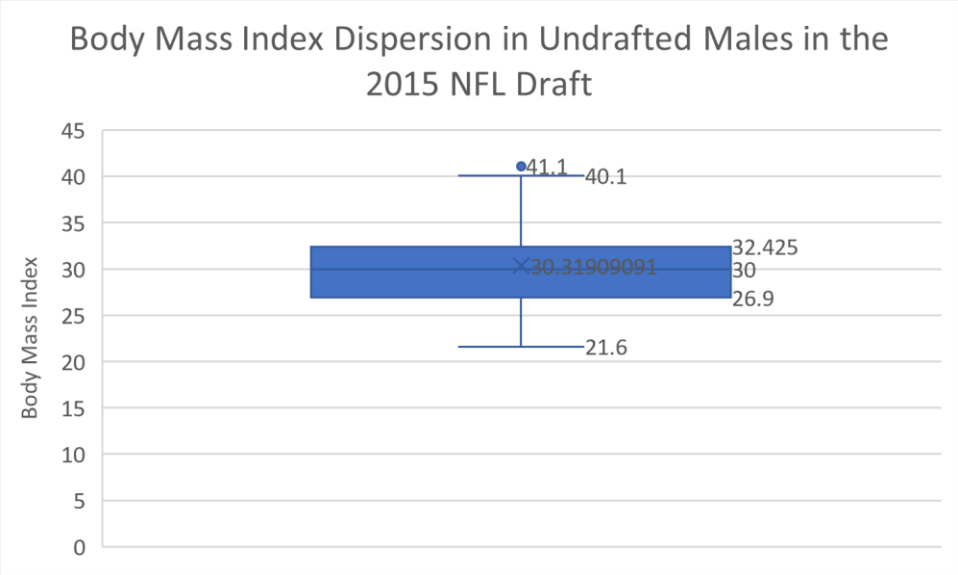
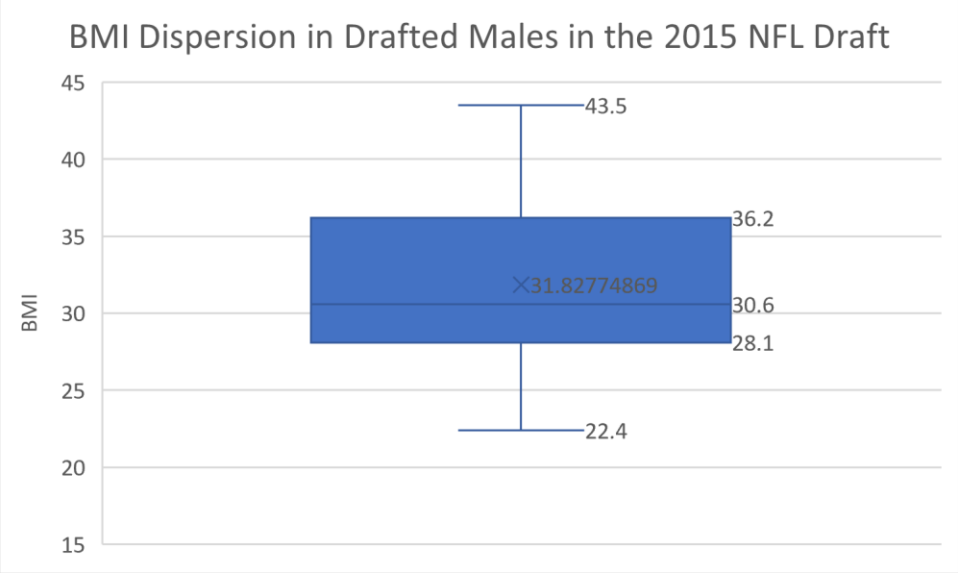


Body Mass Index Dispersion in Undrafted Males in the 2015 NFL Draft



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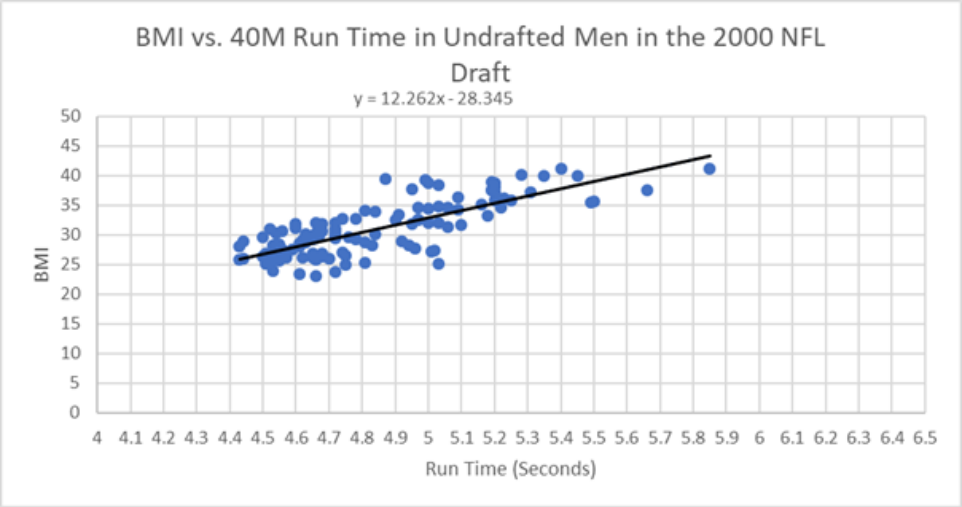
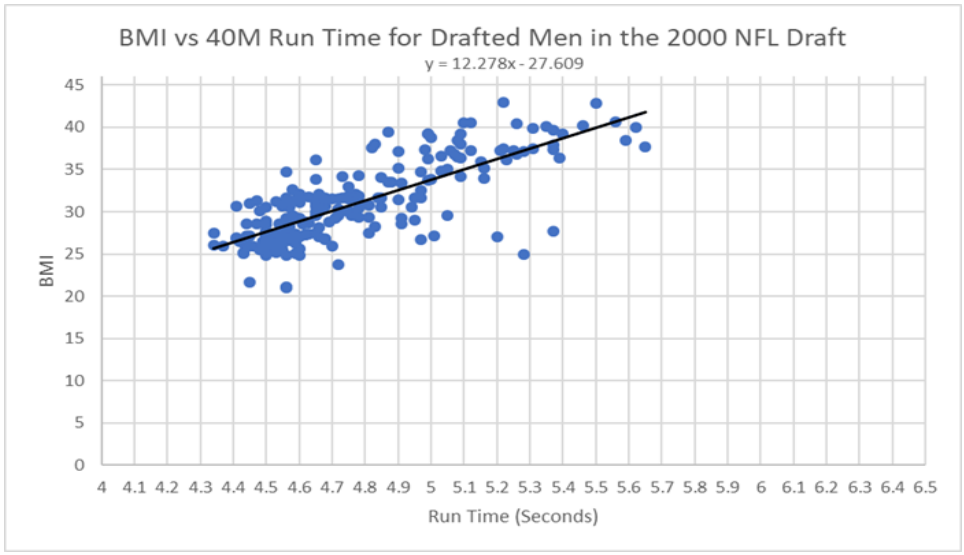


BMI versus 40M Run Time in Undrafted Men in the 2000 NFL Draft



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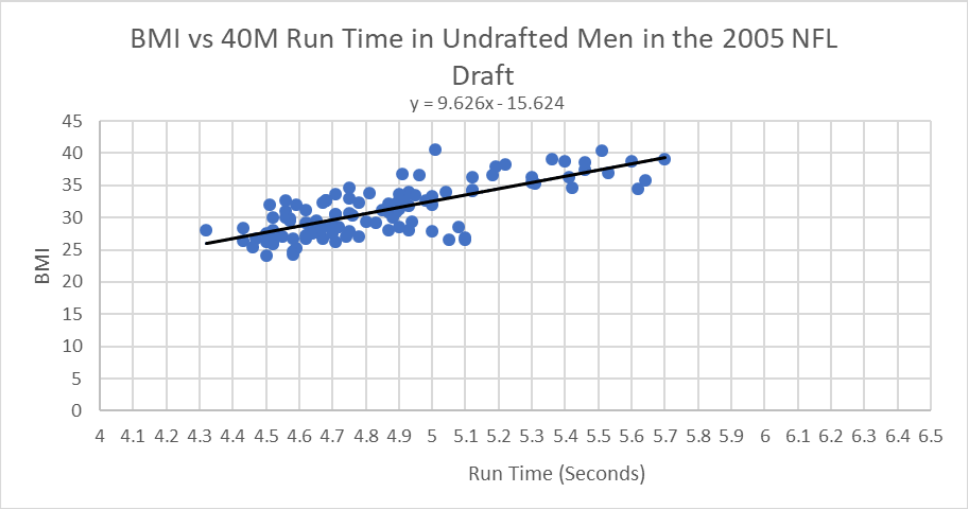

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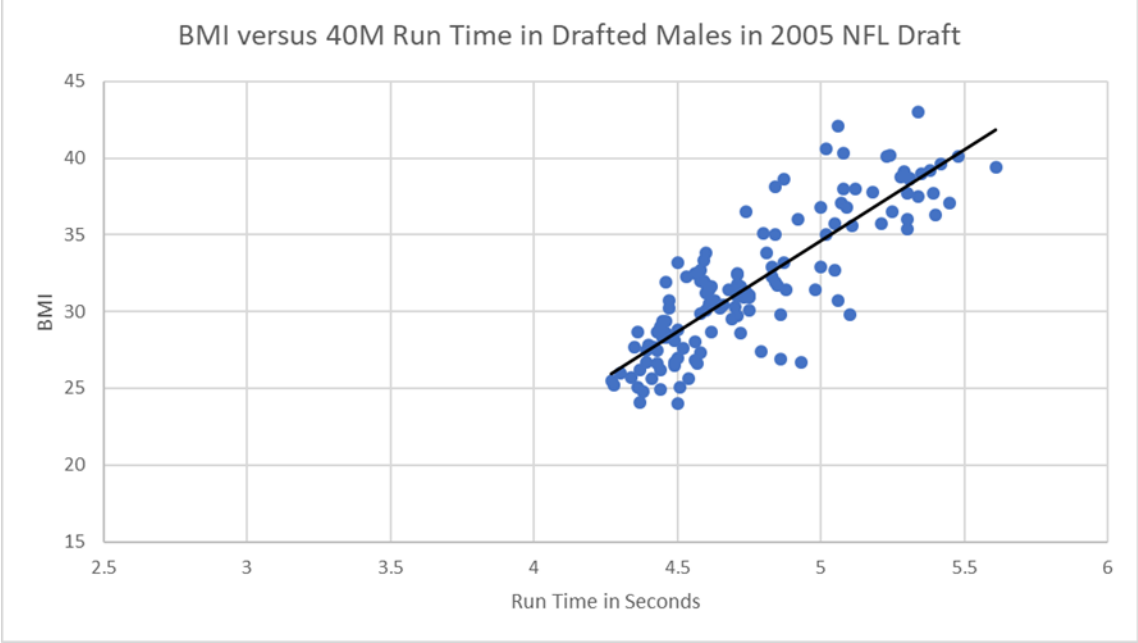

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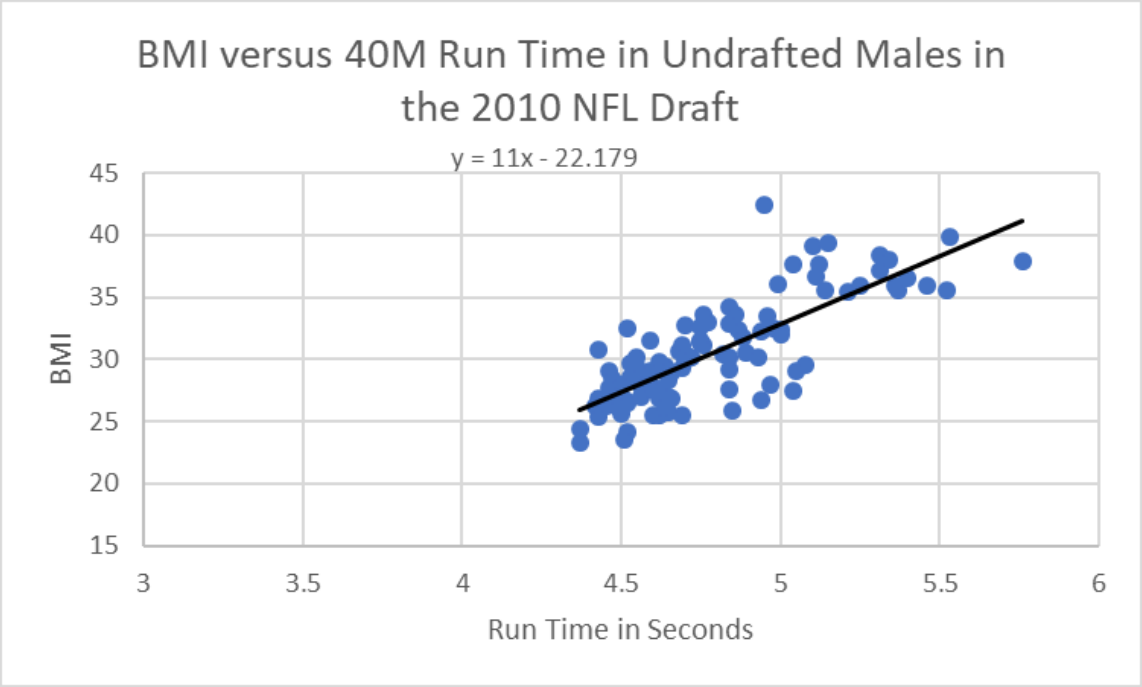

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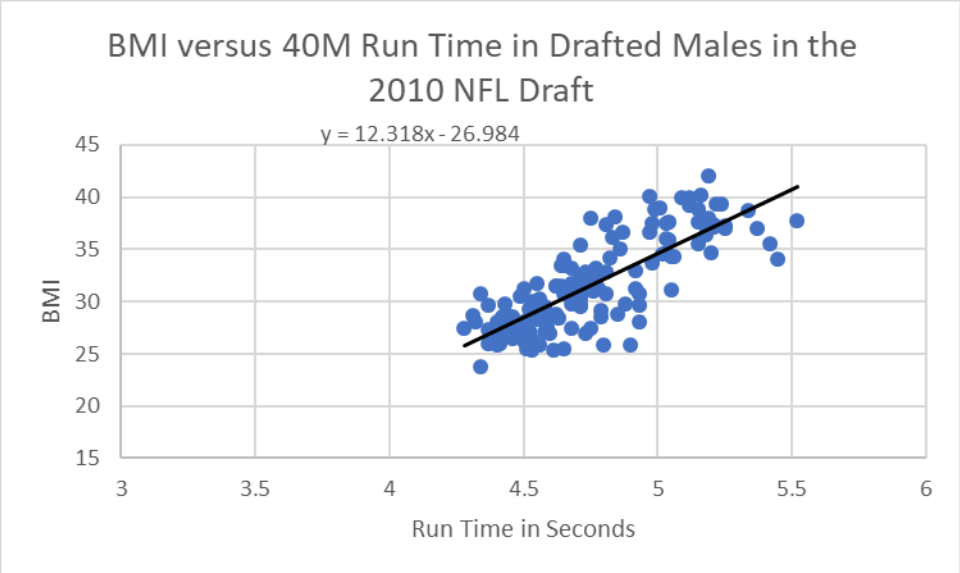

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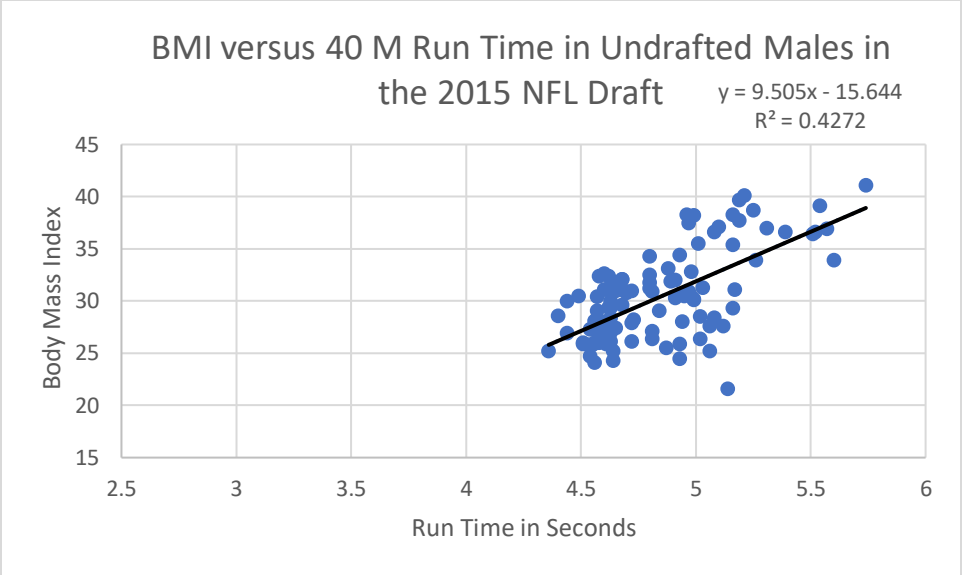

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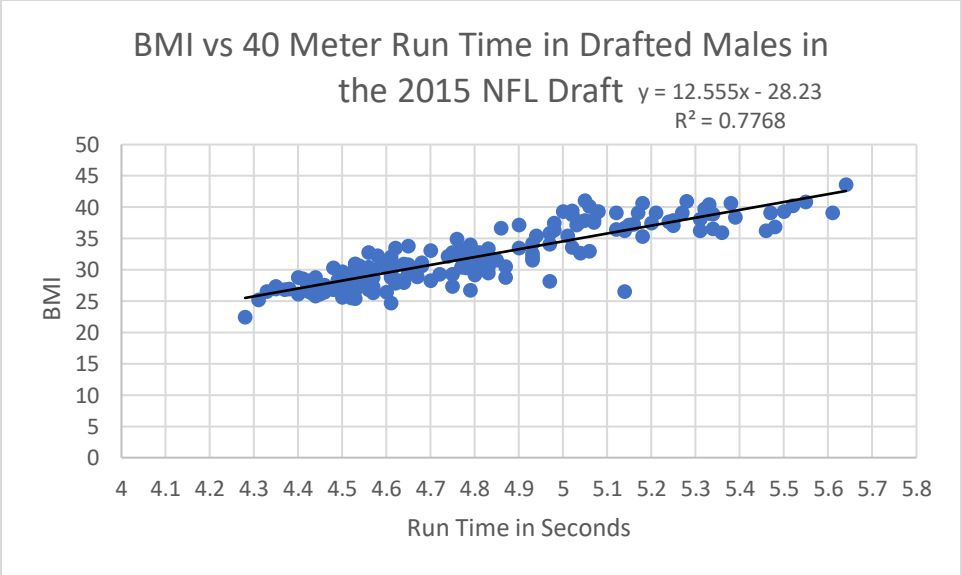
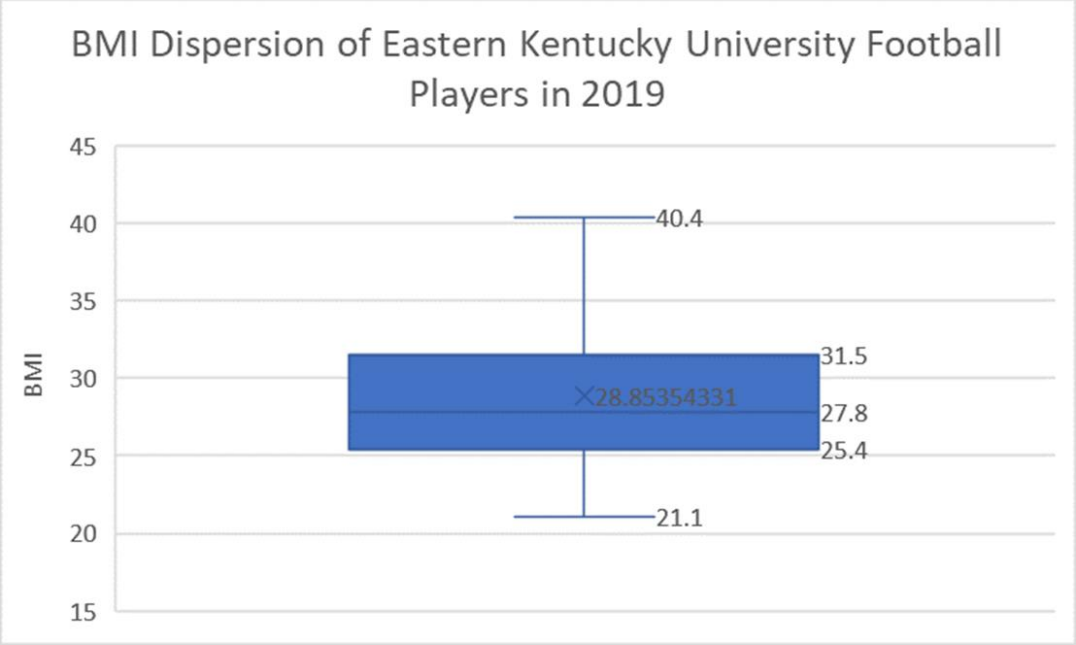


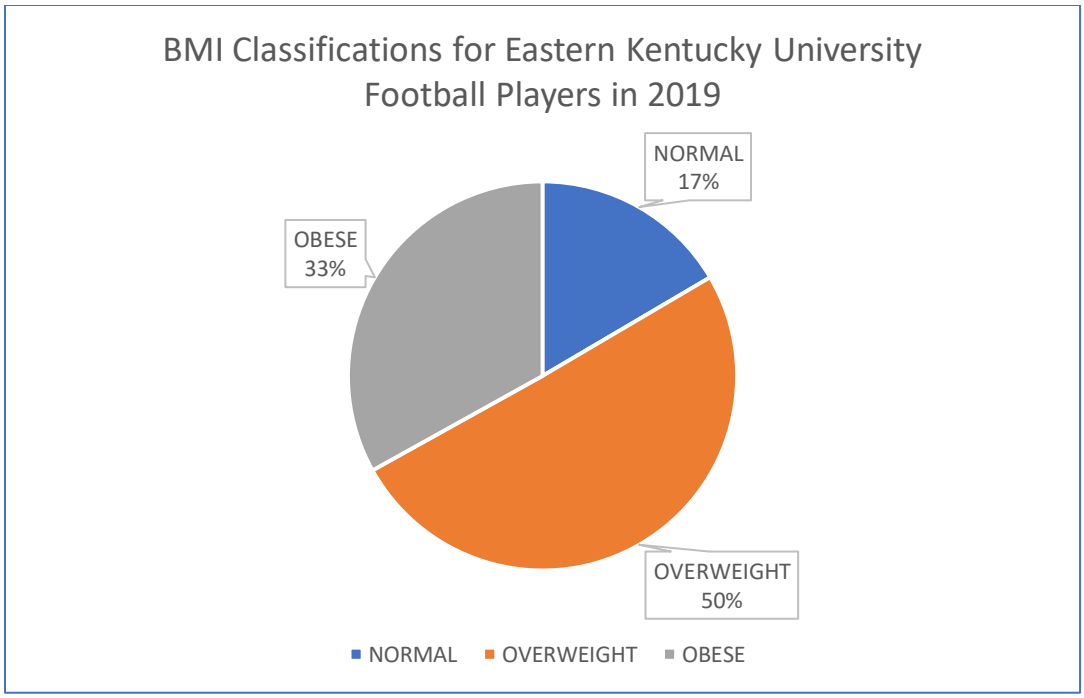
BMI versus 40M Run Time in Drafted Males in the 2015 NFL Draft

Additionally, it was the goal of the researcher to establish the prevalence of obesity and open health discussions among Division I football athletes and the coaching and medical

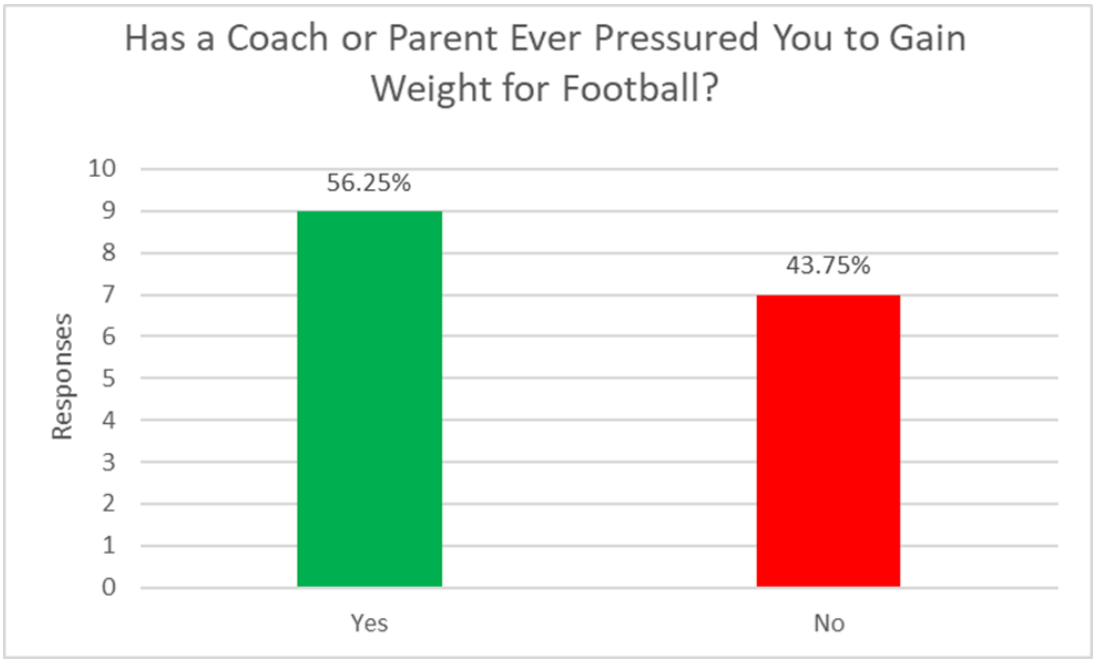
staff they had been exposed to within their playing careers. A survey was designed and distributed to all football players at Eastern Kentucky University who were listed on the travel roster in the 2019 competitive season. Subjects were made aware that their answers were anonymous and that they were not required to participate within the study. Within a subject pool of more than 120 NCAA Division I football players, only 16 voluntarily participated in the anonymous survey. As such, the survey data shown below cannot be qualified as statistically significant but is merely a reflection of the experiences of a small group of high-level athletes. The height, weight, and BMI classification data is publicly available[27], and the researcher was able to design those charts with accurate data as shown below:



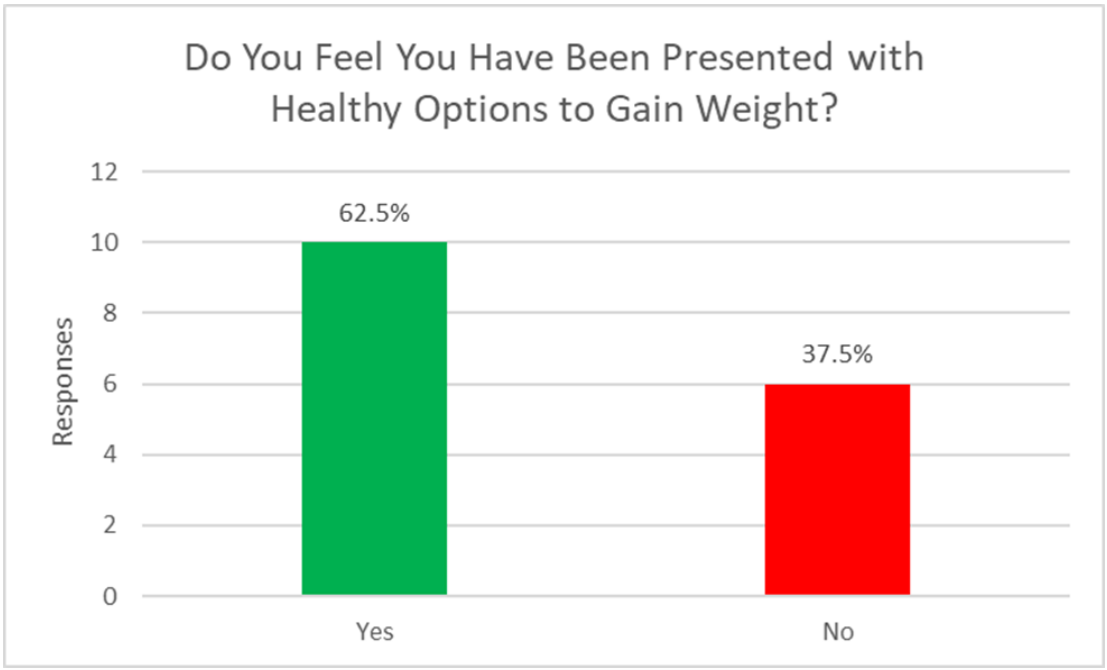
BMI Dispersion of Eastern Kentucky University Football Players in 2019



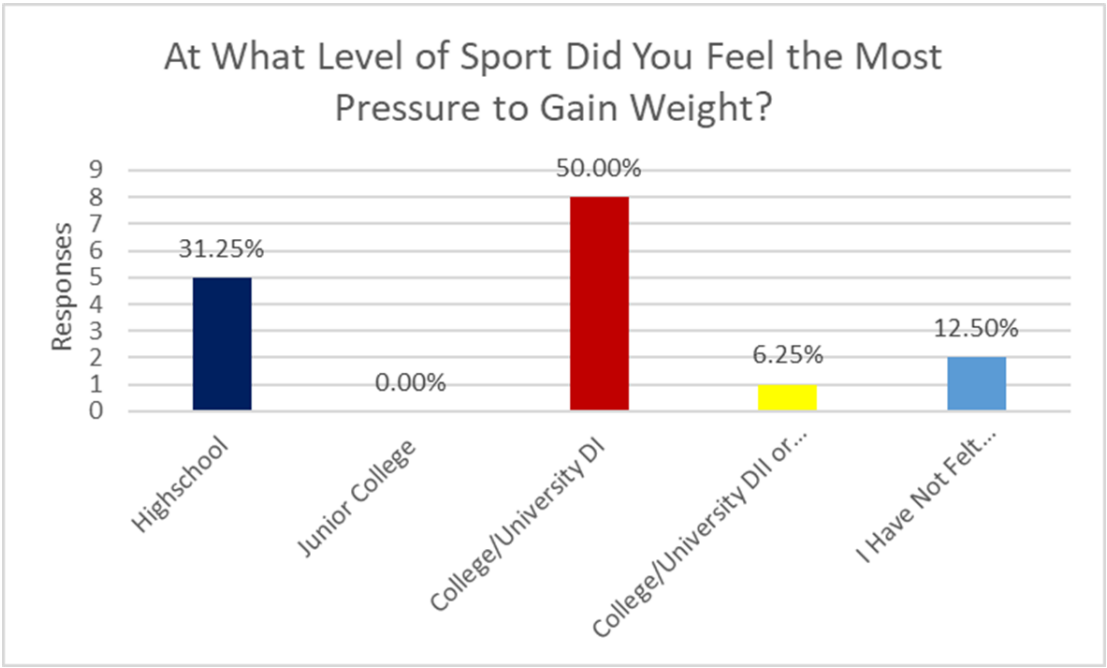
BMI Classifications for Eastern Kentucky University Football Players in 2019



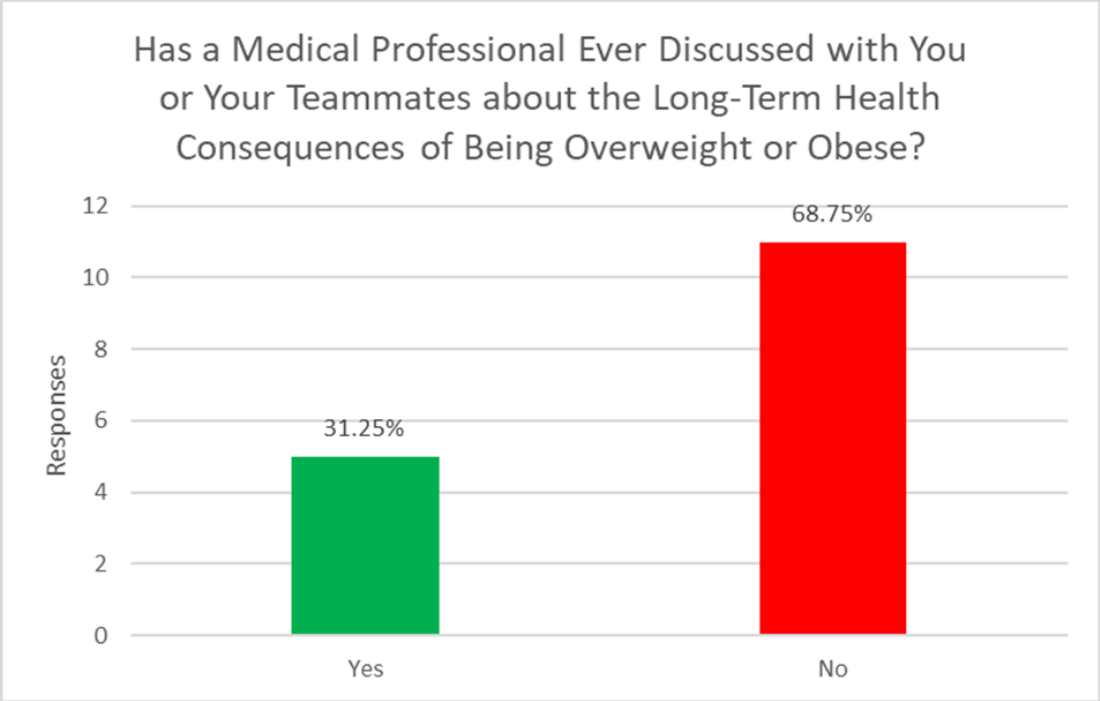
Eastern Kentucky University Football Athletes Who Felt They Had Been Pressured to Gain Weight for Sport



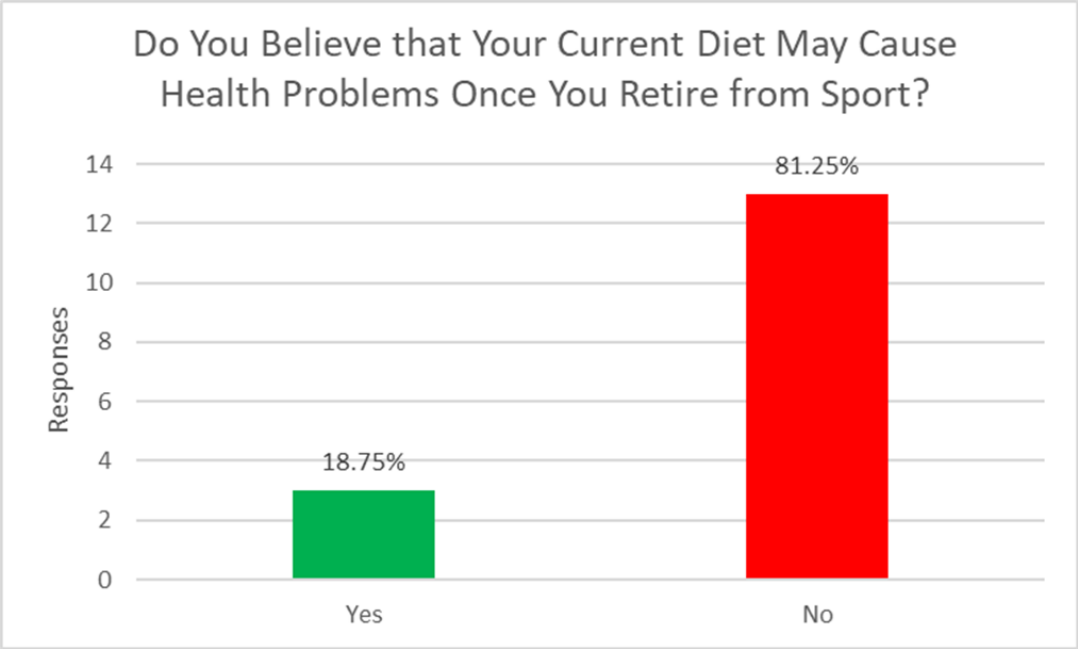
Percentages of Eastern Kentucky University Football Athletes Who Felt They Had or Had Not Been Presented with Healthy Options to Gain Weight



Levels of Competition at which Eastern Kentucky University Football Athletes Claim to have Felt Pressured to Gain Weight



Dispersion of Eastern Kentucky University Football Athletes Who Have Spoken with a Medical Professional Regarding the Health Effects of being Overweight or Obese



Dispersion of Eastern Kentucky University Football Athletes who Believe that Their Current Diet May Cause Health Problems Upon Retirement from Sport

Analysis

Upon analysis of the National Football League (NFL) draft informatics over the course of the past 20 years at five-year intervals, there were no significant differences in the body-mass index classifications between drafted and undrafted males in each draft selection analyzed. Comparisons can be seen in Table 1 below:

Year	Relevant Measure	Drafted	Undrafted
2000	Mean	30.95	30.83
	Maximum	43.0	41.2
	Minimum	21.0	22.6
2005	Mean	31.49	31.07
	Maximum Minimum	43.0	40.5
2010	Mean	31.52	30.37
	Maximum	42.0	42.4
	Minimum	23.8	23.3
2015	Mean	31.83	30.32
	Maximum	43.5	41.1
	Minimum	22.4	21.6

Table 1: Relevant Measures for BMI Dispersion in National Football League Years Analyzed

From the above chart, there are slight differences, with the drafted men generally having slightly higher BMI classifications. Due to the use of the Quintlet formula (weight in kilograms/height in meters to the 2.5^{th} power) to determine the BMI scores in this study, it cannot be determined whether the drafted males are carrying more visceral fat-an indicator of risk for cardiometabolic diseases-or muscular mass because BMI calculations cannot test directly for body composition.

At Eastern Kentucky University, during the 2019 season, it was found that 33% of players were obese, 50% were overweight, and only 17% could be classified as healthy.

Additionally, with the limited survey data available, it was found that 56.2% of athletes surveyed had at some point felt pressured to gain weight for sport purposed, and of those who felt pressured, the majority reported having felt the most pressure at the college or university level. However, 62.5% believed that they had been presented with healthy, nutritious dietary sources throughout the course of the season, and 81.25% did not believe that once they retired from football, they would face any health consequences as a direct result of their current diets. Although this study did not find statistically significant differences in the body mass index classifications of males who were and were not drafted into the National Football League, a study published in the *American Journal of Cardiology* found that there was an increased risk for cardiomyopathy mortality in defensive linemen, but not in offensive linemen. This study also found that players of nonwhite race were at greater risk of cardiomyopathy related death when paired with an in-season body mass index greater than 30.[24]

Disclaimer

Scientists attempted to prove that when determining the inherent risk for cardiometabolic disease of overweight or obese individuals it is more accurate to refer to the waist circumference (WC) of the individual rather than their skin fold test results (SKF) or their body mass index classification (BMI).[20] Collectively, 5217 participants were found to be in conformity with the confines of the study, which required that participants of the first trial be between 6 and 79 years old, participants of the second trial be between 3 and 79 years old, and that all participants complete data on their outcomes of interest written by researchers. All participants had their blood pressure measured and were asked to disclose their current health conditions which were either predicted to extend for a period

of 6 months or had already been affecting the patient for at least 6 months prior to the commencement of the study. Additionally, all participants had their height and weight data collected. Through comparison, it was determined that SKF testing is not a reliable method to classify individuals by weight and could not determine an individual's risk for developing chronic conditions as a result of their SKF test results. However, WC measurements were shown to be easier, less time consuming, more accurate, and a better predictor of an individual person's risk of developing chronic disease when refining BMI classification. Additionally, in obese patients it is less invasive to collect WC data rather than SKF data, as there is only one required measurement instead of many. Researchers also agreed that there was a cut-point for WC measurements which indicated a greater risk for chronic disease: in men this was a WC of 108 centimeters or more, and in women this was a circumference of 88 centimeters or more. The goal of this study was to determine the efficiency of WC versus SKF measurements when stratifying BMI classifications to determine the risk for chronic disease; as WC was proven to be effective in predicting the likelihood of disease, perhaps this is a method by which football medical staff can determine the health risks of their athletes, despite their technically overweight and obese classifications. There was enough data to conclude that when determining an individual's risk for cardiometabolic disease, use of the BMI classification system is adequate in non-athletic or sedentary populations.

However, the Quintlet BMI formula does not consider the differences between muscular weight and visceral fat weight. As such, in highly active or athletic populations, using the BMI scale as the sole measure of overall health is not recommended. It is recommended that exercise physiologists and team staff use more discriminatory methods (skinfold

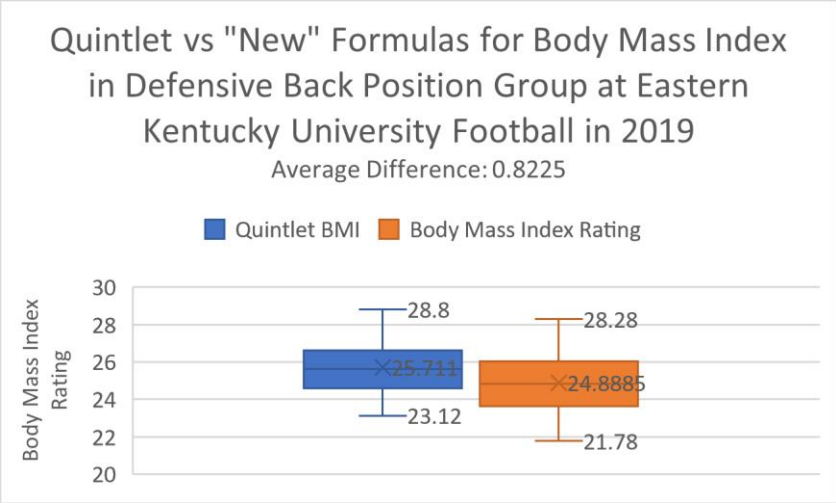
calipers, air displacement plethysmography, dual energy x-ray absorptiometry-DXA) as well as consider the sex, age, and activity level of each individual to determine the patient's or athlete's overall health status.[23]

A study conducted in 2013 utilized an optical device referred to as a Lipometer to detect the thickness of adipose tissue at multiple body sites on both athletes and non-athletes. This study found that in athletes the thickness of their underlying adipose tissue was generally fifty percent lower than that of their non-athletic peers.[25] When comparing body mass index ratings, the athletic and non-athletic populations displayed no statistically significant differences in classifications; proving that in this study the athletes were incorrectly classified by the traditional formula for body mass index, and the most accurate descriptor for their overall health was instead a measure of adiposity.

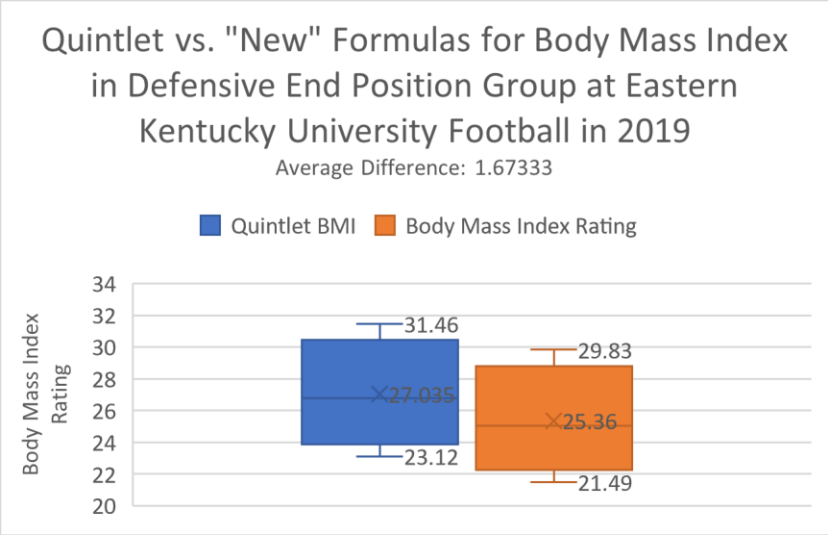
For the purpose of this study, the researcher was unable to access such technology due to constraints on time, financial resources, and the releasing of athlete information from NCAA sanctioned institutions and professional teams. As such, the data collected was based upon the height and weight data publicly provided by the teams and institutions being investigated.

However, there is a proposed amended equation for calculating the body mass index of individuals. This equation was formulated by Oxford mathematician Nick Trefethen, who claims that the original Quintlet formula is too simple and leads to errors in classification in populations who are outside of the normal range of human height. This may result in persons who are short being told that their body mass index is lower than it realistically is, and those who are tall being told that their body mass index is higher. Trefethen proposes that rather than using the traditional equation (BMI= $Kg/m^{2.5}$), instead a

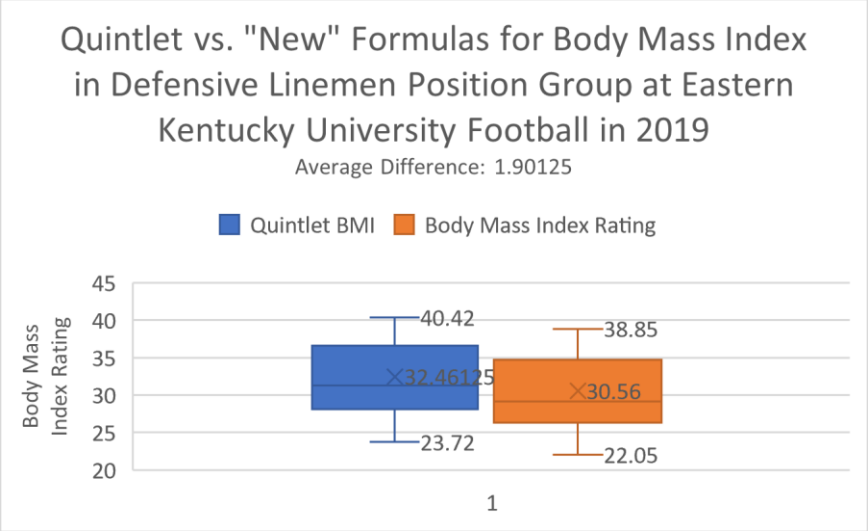
person's weight in kilograms should be multiplied by 1.3, and their height should be raised to the 2.5th power still: BMI=(1.3 x Kg)/m$^{2.5}$.[26] To test for significant differences in the classifications of American Football athletes when utilizing the proposed versus traditional body mass index calculations, the researcher applied the new formula to height and weight data collected for the Eastern Kentucky University 2019 active roster[27]. Comparisons can be see below based upon position groups:



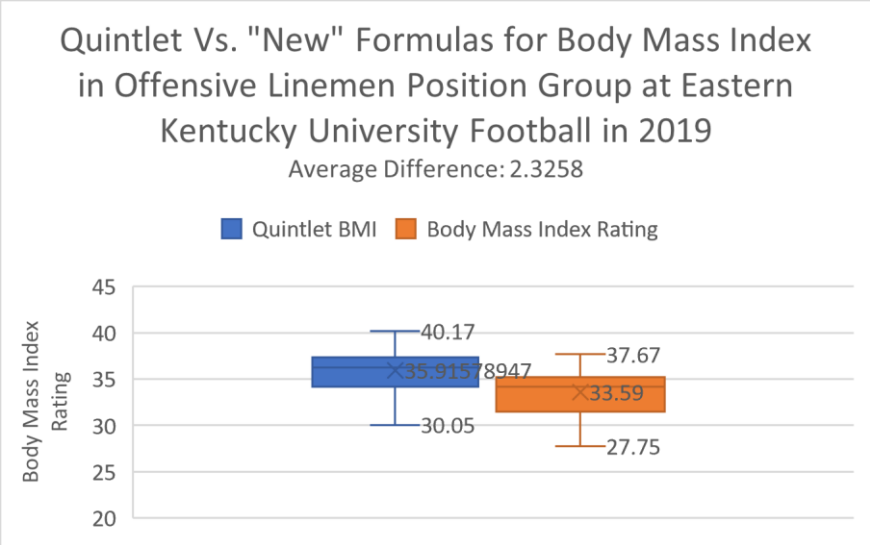
Quintlet versus "New" Formulas for BMI in Defensive Back Position Group at Eastern Kentucky University in 2019



Quintlet versus "New" Formulas for BMI in Defensive End Position Group at Eastern Kentucky University Football in 2019



Quintlet versus "New" Formulas for BMI in Defensive Linemen Position Group at Eastern Kentucky University Football in 2019



Quintlet versus "New" Formulas for BMI in Offensive Linemen Position Group at Eastern Kentucky University Football in 2019

As evidenced by the figures above, Trefethen's amended formula (BMI= [weight in kilograms x 1.3]/height in meters$^{2.5}$) made the most significant difference in position groups where players are generally required by sport to be vastly above average in both height and weight. At Eastern Kentucky University, linemen (both offensively and defensively) saw the greatest difference in body mass index ratings when comparing the results of the Quintlet and Trefethen equations, while defensive backs and defensive ends saw smaller differences of 0.8225 and 1.67333 respectively. Offensive linemen being on average 2.3258 points lower and defensive linemen being on average 1.90125 points lower based on Trefethen's revised method. Despite this, all offensive linemen and seventy-five percent of defensive linemen still fall within the categories of overweight or obese. This indicates that although their body mass index ratings are affected by the amended equation, they are still at an increased risk for the development of

cardiometabolic disease and its associated risk factors based upon their body mass index classifications.

Significance

American football players stand as an example of the incredible things that the human body can do in sport; however, it is in this desire for excellent performance that athletes at all ages are pushing their bodies to possibly unsafe limits. These young men are still human, but unfortunately due to the earning potential of the American football industry these athletes may be viewed as disposable and easily replaced by their franchise owners or coaches. It is because of this that many athletes do not report injuries, do not take time to fully recover from injuries they have reported, and do not contend with directions to gain weight when coming from coaching staff or franchise directors. Over time, the observable increase in the average weight of the American football player has increased to a level which may become a risk to the athletes cardiometabolic health during and especially after sport participation. The effects of this trend have been shown to trickle down into nearly every level of competition, and the consequences span beyond cardiometabolic disease risks. Reports state that nearly 81% of college freshmen football players want to gain weight for sport[21]. Additionally, it was found that players who are overweight or obese are at greater risk (2.03 vs 0.53 for non-obese teammates) for non-contact ankle sprains and consequent re-injury throughout the course of both pre-season and active competition[22].

Despite this trend, it is the direct responsibility of coaching staff, medical professionals, and franchise owners to at the very least not endanger the health or longevity of their players for the sake of a finite athletic career. As such, medical professionals need to

begin to work more closely in conjunction with team staff at all levels of competitive American football in order to ensure the long-term performance capabilities and overall health of players at all levels of competition. One proposed solution is to enact protocols which would make blood panels a mandatory portion of annual physical health screenings. Through these blood panels, physicians and athletes will be able to monitor not only changes in weight, but also changes in more important contributing factors such as increases in blood pressure, HDL and LDL cholesterol levels, and screen for general fat levels in the bloodstreams of athletes at all levels. These blood panels would enable a more well-rounded approach to monitoring overall athlete health and may serve as a more discriminating factor in determining the risk for cardiometabolic disease development in professional and collegiate American football athletes.

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