

# Prevalence of Metabolic Syndrome in Retired National Football League Players

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The National Institute of Occupational Safety and Health mortality study of National Football League (NFL) players concluded that retired NFL linemen have an increased risk of cardiovascular death compared with both nonlinemen and the general population. Though elevated body mass index contributed to the increased cardiac risk of linemen, it could not fully account for the mortality observed, suggesting that other unmeasured cardiovascular risk factors were involved. We performed a cross-sectional prevalence study of metabolic syndrome (MS), and its individual component criteria, in 510 retired NFL players who were recruited to multicity health screenings from February 2004 through June 2006. The International Diabetes Federation criteria were used to define MS. The MS component criteria of body mass index  $>30 \text{ kg/m}^2$ , reduced high-density lipoprotein, and raised fasting glucose were more prevalent in linemen compared with nonlinemen (85.4% vs 50.3%,  $p < 0.001$ ; 42.1% vs 32.7%,  $p = 0.04$ ; 60.4% vs 37.6%,  $p < 0.001$ , respectively). Metabolic syndrome was more prevalent in linemen compared with nonlinemen (59.8% vs 30.1%,  $p < 0.001$ ). In conclusion, linemen exhibited a high prevalence of MS, almost double the prevalence of their nonlinemen counterparts. These findings may partially explain the increased risk for cardiovascular death observed in retired linemen and could have significant public health implications for preprofessional training regimens and postprofessional health maintenance. © 2008 Elsevier Inc. All rights reserved. (Am J Cardiol 2008;101:1281–1284)

In 1994, the National Institute of Occupational Health and Safety completed a study of retired National Football League (NFL) players in response to concerns of early mortality.<sup>1</sup> Overall, former NFL players had a decreased risk of death compared with the general population, but when stratified by position played, offensive and defensive linemen had an increased risk of cardiovascular disease compared with players at other positions. Specifically, linemen had a 52% greater risk of cardiovascular death compared with the general population and 3 times the risk of dying from heart disease compared with nonlinemen. Greater body mass index (BMI) may have contributed to the

cardiovascular deaths of linemen but could not fully explain the observed mortality, suggesting that other unmeasured cardiac risk factors were involved. Variables such as dyslipidemia, insulin resistance, and hypertension status are well-established cardiovascular risk factors and are individual components of the metabolic syndrome (MS) but were not accounted for in this earlier study. We hypothesized that the MS would be more prevalent in retired NFL linemen compared with nonlinemen.

## Methods

The Living Heart Foundation, a nonprofit organization, conducted open multicity health screenings for retired NFL players from February 2004 through June 2006. In conjunction with the NFL Players Association, retired NFL players were recruited to the health screenings either through direct mailing or communications at local player chapter meetings. As a result, 510 participants self-reported demographic, medical, and professional career information. Height, weight, and cuff blood pressure readings were recorded on the day of screening. Two cuff blood pressure readings were obtained, with the mean systolic and diastolic values used for analysis. Fasting high-density lipoprotein (HDL) cholesterol, triglycerides, and plasma glucose levels were determined using the Cholestec LDX (Hayward, California) desktop chemical analyzer.<sup>2</sup> Data on specific therapy for elevated triglycerides were not available. Body mass index (BMI) was defined as weight (in kilograms) divided by the square of the height (in meters). For the comparisons between our cohort and data from the National Health and

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Table 1  
Baseline demographic, career, and medical information

Variables	Linemen (n = 164)	Nonlinemen (n = 346)	p Value
Age, mean (SD) (yrs)	54.0 (12.5)	53.5 (11.5)	0.67
Years played in NFL, mean (SD)	6.8 (3.5)	6.0 (3.7)	0.02
Years since retirement*, mean (SD)	24.4 (12.3)	25.0 (11.8)	0.59
Height, mean (SD) (meters)	1.91 (0.05)	1.84 (0.06)	<0.001
Weight, mean (SD) (kg)	127.3 (18.2)	104.0 (15.2)	<0.001
BMI, mean (SD) (kg/m <sup>2</sup> )	34.9 (4.9)	30.7 (4.0)	<0.001
Percent body fat, mean%	31.4	27.4	<0.001
Percent body fat $\geq$ 28%	111 (67.7%)	145 (41.9%)	<0.001
Systolic blood pressure <sup>†</sup> , mean (SD) (mm Hg)	137.1 (21.3)	131.9 (17.4)	0.01
Diastolic blood pressure <sup>†</sup> , mean (SD) (mm Hg)	79.2 (13.3)	78.5 (11.4)	0.56
Total cholesterol (SD) (mg/dl)	189.1 (43.9)	195.6 (38.6)	0.09
Triglycerides, mean (SD) (mg/dl)	128.5 (79.8)	116.1 (70.8)	0.08
HDL, mean (SD) (mg/dl)	44.5 (14.2)	47.6 (14.9)	0.03
Fasting glucose <sup>‡</sup> , mean (SD) (mg/dl)	104.6 (22.6)	97.4 (15.7)	<0.001
History of smoking	8 (4.9%)	19 (5.5%)	0.83
Hypertension <sup>§</sup>	41 (25.0%)	71 (20.5%)	0.25
Diabetes <sup>  </sup>	17 (10.4%)	14 (4.0%)	0.01

\* At time of screening.

<sup>†</sup> Excluding players with previously diagnosed or treated hypertension.

<sup>‡</sup> Excluding players with previously diagnosed or treated diabetes.

<sup>§</sup> History of diagnosed or treated hypertension.

<sup>||</sup> History of diagnosed or treated diabetes.

Table 2  
Prevalence of metabolic syndrome and component criteria

Variables	Linemen (n = 164)	Nonlinemen (n = 346)	p Value
BMI >30 kg/m <sup>2</sup>	140 (85.4%)	174 (50.3%)	<0.001
Raised blood pressure	111 (67.7%)	212 (61.3%)	0.16
Reduced HDL cholesterol	69 (42.1%)	113 (32.7%)	0.04
Raised fasting glucose	99 (60.4%)	130 (37.6%)	<0.001
Raised triglycerides	51 (31.1%)	83 (24.0%)	0.09
Metabolic syndrome	98 (59.8%)	104 (30.1%)	<0.001

Raised blood pressure defined as  $\geq$ 130 mm Hg, diastolic  $\geq$ 85 mm Hg, or treatment of previously diagnosed hypertension; reduced HDL cholesterol defined as <40 mg/dL; raised fasting glucose defined as  $\geq$ 100 mg/dl or previously diagnosed type 2 diabetes. See Methods for fulfillment criteria of metabolic syndrome.

Nutrition Examination Survey (NHANES), obesity was defined as a BMI  $\geq$ 30 kg/m<sup>2</sup>.<sup>3</sup>

Percentage body fat (%BF) was calculated using a Tanita leg-to-leg bioelectrical impedance fat analyzer (Arlington Heights, Illinois).<sup>4</sup> Based upon previously published age- and sex-specific reference values, we considered a %BF of  $\geq$ 28% an indicator of obesity.<sup>5</sup>

The presence of MS was classified according to the International Diabetes Foundation criteria,<sup>6</sup> modified to use a BMI >30 kg/m<sup>2</sup> to define central obesity instead of waist circumference. The MS was diagnosed in patients with a BMI >30 kg/m<sup>2</sup> and 2 or more of (1) systolic blood pressure  $\geq$ 130 mm Hg, diastolic blood pressure  $\geq$ 85 mm Hg, or treatment for known hypertension; (2) HDL cholesterol <40 mg/dl; (3) fasting plasma glucose  $\geq$ 100 mg/dl or a history of type 2 diabetes; or (4) fasting triglycerides  $\geq$ 150

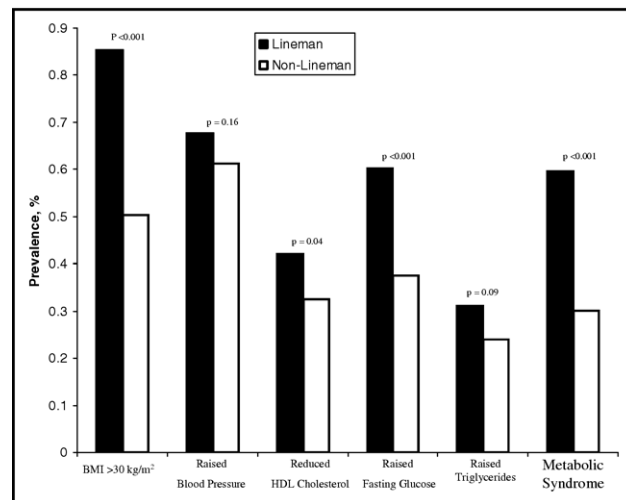


Figure 1. Prevalence of metabolic syndrome and component criteria in retired NFL players by position. BMI = body mass index; raised blood pressure defined as  $\geq$ 130 mm Hg, diastolic  $\geq$ 85 mm Hg, or treatment of previously diagnosed hypertension; reduced HDL cholesterol defined as <40 mg/dL; raised fasting glucose defined as  $\geq$ 100 mg/dl or previously diagnosed type 2 diabetes. See Methods for fulfillment criteria of metabolic syndrome.

mg/dl. These studies were approved by the institutional review board.

Continuous variables are presented as mean  $\pm$  standard deviation and as numbers and percentages. Linemen were compared with nonlinemen for all listed variables using either a Student's *t* test or chi-square test, as appropriate. In cases in which categorical data were compared and <10 patients populated a group, a Fisher's exact *t* test was used. Statistical significance was considered when *p* values were

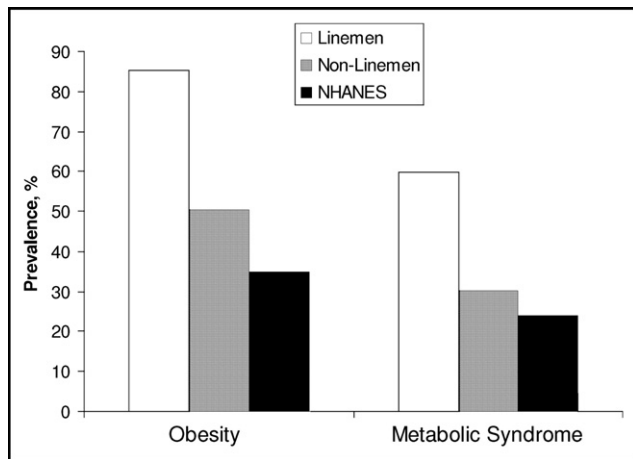


Figure 2. Prevalence of obesity and metabolic syndrome in retired NFL players compared with United States adult males. Prevalence of obesity was compared with similarly aged males (40 to 59 years) in NHANES, 1999 to 2004.<sup>3</sup> Prevalence of metabolic syndrome was compared with male adults ( $\geq 20$  years) in NHANES, 1994 to 1998.<sup>10</sup> Body mass index (BMI) was defined as weight (in kilograms) divided by the square of the height (in meters). Obesity defined as a BMI  $\geq 30$  kg/m<sup>2</sup>. Metabolic syndrome in linemen and nonlinemen was determined by the International Diabetes Federation definition (see Methods). Metabolic syndrome in NHANES defined by Adult Treatment Panel (ATP) III criteria.

$<0.05$ . All data were entered into and analyzed by Statview 5.0.1 (SAS Institute, Inc., Cary, North Carolina).

## Results

There were no significant differences between linemen and nonlinemen in age, years since retirement, diastolic blood pressure, total cholesterol, triglyceride level, history of smoking, or history of previously diagnosed or treated hypertension (Table 1). Linemen served for a longer duration in the NFL and exhibited greater height, weight, BMI, %BF, systolic blood pressure, and fasting glucose and lower HDL levels compared with nonlinemen. Previously diagnosed or treated diabetes was more prevalent in linemen compared with nonlinemen (10.4% vs 4.0%,  $p = 0.01$ ). A significantly larger percentage of linemen had a %BF indicative of obesity (67.7% vs 41.9%,  $p < 0.001$ ) compared with nonlinemen.

The MS was present in 59.8% of retired linemen and 30.1% of retired nonlinemen ( $p < 0.001$ ; Table 2; Figure 1). With regard to the individual component criteria of the MS, obesity (defined as a BMI  $>30$  kg/m<sup>2</sup>) was more prevalent in linemen compared with nonlinemen (85.4% vs 50.3%,  $p < 0.001$ ), as were reduced HDL cholesterol (42.1% vs 32.7%,  $p = 0.04$ ) and raised fasting glucose (60.4% vs 37.6%,  $p < 0.001$ ). There was no statistically significant difference between the groups in the prevalence of raised triglycerides or raised blood pressure.

## Discussion

Metabolic syndrome, an established cardiovascular risk factor,<sup>7,8</sup> was significantly more prevalent in retired NFL linemen compared with nonlinemen. Almost 60% of retired linemen had evidence of MS, compared with fewer than

one-third of retired nonlinemen (Figure 1). Three of the MS component criteria—BMI  $>30$  kg/m<sup>2</sup>, reduced HDL cholesterol, and raised fasting glucose—were significantly more prevalent in retired linemen compared with nonlinemen. The increased prevalence of MS, and its component criteria, may help explain, at least in part, the greater risk of heart disease-related death observed in retired linemen.

An overwhelming majority (85.4%) of the retired linemen were obese (defined as a BMI  $\geq 30$  kg/m<sup>2</sup>), which is considerably greater than the prevalence of obesity in nonlinemen (50.3%) and similarly aged adult males in the United States (34.8%), according to data from NHANES, 1999 to 2004 (Figure 2).<sup>3</sup> With the MS and its increased risk of incident cardiovascular mortality intimately tied to obesity,<sup>9</sup> it is not surprising that the prevalence of MS was also greater in linemen (59.8%) compared with both nonlinemen (30.1%) and adult males in the United States (24%), according to data from NHANES, 1988 to 1994 (Figure 2).<sup>10</sup>

Our study of the prevalence of MS in retired NFL players has some limitations. First, because our study subjects were recruited to an open health screening, self-selection bias could result in a greater prevalence of MS than the general population of retired NFL players. In mitigation, this limitation would apply to both linemen and nonlinemen, and therefore cannot explain the greater prevalence of MS we noted in linemen versus nonlinemen. Second, since waist circumference measurements were not available, we used BMI  $>30$  kg/m<sup>2</sup> to define central obesity, which is an acceptable substitution according to the International Diabetes Foundation consensus statement because more than 95% of individuals with a BMI  $>30$  kg/m<sup>2</sup> have a waist circumference above the gender- and ethnic-specific threshold values.<sup>6</sup> Although BMI is a widely recognized and validated anthropometric index of obesity in epidemiological studies,<sup>3</sup> we recognize that it is not a direct measure of adiposity and can overestimate the prevalence of obesity in certain populations.<sup>11</sup> However, when BMI is high ( $\geq 30$  kg/m<sup>2</sup>), it has excellent specificity ( $>90\%$ ) to detect obesity, and the substitution of BMI  $>30$  kg/m<sup>2</sup> in place of waist circumference does not affect the ability of MS to predict diabetes or cardiovascular events.<sup>8,12,13</sup> Although bioelectrical impedance analysis is a relatively simple and accurate means of estimating %BF,<sup>14</sup> it has inherent limitations compared with more conventional measurement techniques. Finally, the previous use of anabolic androgenic steroids, which could have multiple deleterious effects on the cardiovascular system, such as altering lipid profiles, promoting atherosclerosis, enhancing thrombogenesis, and altering body mass composition,<sup>15</sup> was not known for either linemen or nonlinemen.

This study is the first and largest analysis of cardiovascular risk factors in retired NFL players. Metabolic syndrome was present in 60% of retired NFL linemen, almost double the prevalence of MS in nonlinemen. These findings could have implications for both active training regimens and postprofessional health maintenance. Though preparticipation screening strategies exist for the detection of cardiovascular disease in young and middle-aged athletes who are either entering or continuing organized sports competition,<sup>16,17</sup> there is a paucity of information as to how athletes should be cared for in their postprofessional years.

For the vast majority of professional athletes, obesity and its metabolic consequences are unlikely to be a major concern. However, considering the increasing body size required to stay competitive in professional football,<sup>18</sup> the high prevalence of obesity in active NFL linemen,<sup>19</sup> and finally, our data demonstrating a high prevalence of MS in retired linemen, it is prudent to begin focusing on the cardiovascular and metabolic costs of such lifestyle and career choices. Lifestyle modifications, such as weight reduction, exercise, and avoidance of an atherogenic diet can reduce the metabolic risk factors, and their importance should be emphasized even in former elite athletes.<sup>20</sup> Furthermore, our results could have public health implications for the many high school and college athletes who are encouraged to bulk up and achieve unhealthy body weights to remain competitive<sup>21,22</sup> yet never enter professional sports.

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