



since 1972 and had at least one credited season. The average age at first season played was 23.

To determine whether players were living or dead (their "vital status") we used mailed questionnaires, Social Security Administration death tapes, Internal Revenue Service records, pension records for vested players, and the National Death Index, which contains records on all deaths in the United States between 1979 and the end of 1991. Using these records, 99% of the group's vital status was determined through December 31, 1991. For the purposes of analysis, the remaining 1% was considered to be alive through 1991. There were a total of 139 deaths in the entire group of 6,848. Table 2 shows the distribution by year of these deaths.

Our analysis of mortality looks at the ratio of players' deaths to the expected deaths in the general United States population of a similar age and racial mix. This ratio is called a standardized mortality ratio (SMR). If the SMR is less than 1.0, then the rate of death in the study population is less than the rate of death in the general population. If the SMR is above 1.0, then the rate of death is greater among players than in the general population. For example, if the SMR were 1.40, then the rate of death in the study population would be 40% greater than in the general population. SMRs were calculated for all deaths combined, and for specific causes of death, such as lung cancer. All SMRs were calculated using the NIOSH lifetable analysis program.<sup>2</sup>

Since this study population included only vested players prior to 1972, for our analysis, the entire population was placed in two separate study populations. Population 1, with 3,420 players, included those with at least five credited seasons between 1959 and 1988. Population 2, with 3,428 players, included those with one to four credited seasons between 1972 and 1988. Those who played between 1959 and 1972, but played less than five credited seasons are not included in this study.

In epidemiological studies, we convert the number of players and the total years lived since they began playing football into "person-years" alive and at risk of death. In population 1, there were a total of 51,689 person-years at risk, 34,880 (67%) white and 16,808 (33%) non-white. For our analysis, race is defined according to the U.S. census definition where white includes Hispanic and non-white includes all others.

In Population 1, there were 103 deaths. Table 3 shows the results of the SMR analysis for Population 1. The 95% confidence interval appearing in the table represents the range within which the SMR has a 95% probability of falling. If the lower limit is above 1.0 then the increase in the SMR is said to be statistically significant. Similarly, if the upper confidence limit is below 1.0 then the decrease in the SMR is said to be statistically significant.

Population 2 is younger, and consequently had fewer deaths, 36 in all. It contained a total of 33,022 person-years at risk, 17,237 (52%) white and 15,786 (48%) non-white. Table 4 shows the results of the SMR analysis for Population 2.

These tables show that, overall, professional football players have a statistically significantly decreased risk of death compared to the general United States population. For those who played at least five seasons, the rate of death was 46% less than that of the general population with a similar age and racial makeup. For those with less than five seasons, who played after 1972, we found a 58% decrease in deaths. However, a more detailed analysis of these tables shows some interesting

and important patterns.

First, concern had been expressed about the potential for players to die of violence and accidents. However, this analysis shows that players of both racial groups had a substantially decreased risk of death due to these causes.

Second, questions have been raised about a possible increased risk of cancer. This analysis shows that, overall, the players' risk of cancer is not increased. However, while there seemed to be a decreased risk of certain cancers, other cancers appeared to have occurred at a higher rate. These differences were not statistically significant, and, because of the small numbers, it is impossible at this time to determine whether the increased SMRs represent chance occurrences or true associations with playing professional football. Further follow-up of this cohort over time should clarify this.

Third, there is an increase in nervous system disorders which also is not statistically significant. This increase is due to four cases of amyotrophic lateral sclerosis (ALS), commonly known as Lou Gehrig's disease. A few years ago, it was reported that three players who played on the same team (San Francisco), during the same years, subsequently developed ALS. In addition to those three cases, we found a fourth. This player did not play for San Francisco, but did play on a team at the same time as one of the other three cases. The causes of ALS are not clearly understood thus making it difficult to assess a potential association with playing professional football. As with the elevation in cancers, further follow-up of this cohort over time should clarify whether this increase is due to chance.

Finally, because of interest in heart diseases among athletes, we decided to further explore the cardiovascular causes of death. To investigate this further, we stratified the cohort by position played. This stratification was restricted to Population 1 (those with five or more seasons), since the other population had too few deaths to make the results meaningful. We divided the positions into three categories according to group differences in physical size of the players. Category 1 included quarterbacks, defensive backs, wide receivers, kickers, and special teams and contained 1197 players and 17,913 person-years. Category 2 included running backs, linebackers, and tight ends with 1062 players and 15,533 person-years. Category 3 included offensive and defensive linemen with 1160 players and 18,215 person-years. Size was expressed in terms of body mass index (BMI), which is defined as weight (in kilograms) divided by the square of the height (in meters). BMI was divided into three categories: less than 28, 28-31, and 32 or greater. A male in the general population is considered obese if his BMI is 28 or greater. For example, Table 5 shows the weight in pounds which corresponds to a BMI of 28 and 32 for heights 5'11" to 6'3". Table 6 shows the distribution by race and BMI category for each of the three position categories.

Separate SMRs were generated for each of the three position categories (Table 7). This table shows a higher mortality rate for the linemen than for the other two position groups. This higher mortality rate is primarily due to cardiovascular diseases where we found a 52% increase in cardiovascular mortality among linemen compared to the general population. Although this increased SMR was not quite statistically significant (lower 95% confidence limit of 0.95), it was three times the SMR of the other two position groups.

Our stratified rates also showed a statistically significant increase in Hodgkin's disease, a type of lymphoma, among the linemen. This increase results from only two cases that both played in the late 60's and 70's, but on different teams. Both were diagnosed with Hodgkin's disease either while playing or very shortly after they stopped playing professional football. One occurred after five seasons of playing, the other after 14 seasons. Because there were only two cases, it is difficult to draw any conclusions regarding etiology.

In order to further explore the increase in cardiovascular mortality, we conducted a nested case-control study. This additional analysis allows us to determine the increased risk for cardiovascular disease due to specific risk factors such as position played and BMI. For this case control study, each player who died of cardiovascular disease was matched with up to 10 other players who lived to at least the age of the deceased player. In order to include players from both Population 1 and 2, we also matched the deceased players with those who had a similar number of credited seasons.

Amongst the total of 139 deaths, there were 38 cardiovascular deaths which are described in Table 8. Conditional logistic regression analysis (using SAS 6.04 PHREG) was done in which we examined the contribution of position played, BMI, race, duration of playing, and whether the person played during the early years or more recently. This last variable was examined by categorizing players into those who played primarily during the first half of the study period (before 1975) and those who played primarily after 1975. We found a significantly increased risk for cardiovascular disease due to position played, BMI, and race. Since BMI and position played were so highly correlated, separate risk models were developed. The results of this analysis are shown in Table 9. This table shows that linemen had a 3.7 times greater risk of cardiovascular disease than other positions. Additionally, those in the highest BMI category had a 6 times greater risk of cardiovascular disease than those in the lowest BMI category. In both models, non-whites had a 1.7 times greater risk than whites.

In conclusion, this study found that overall, professional football players had a 46% lower overall mortality rate than the general United States male population with a similar age and race distribution. However, those who played on the offensive and defensive line had a 50% greater risk of cardiovascular disease than the general population. When compared to other football players, the linemen had a 3.7 times greater risk of cardiovascular disease. Those in the largest BMI category (32 or greater) had a 6 times greater risk than those players who were in the lowest BMI category. An association with position and BMI was found both for ischemic and non-ischemic causes of cardiovascular deaths. It is not possible from this analysis to determine specifically what it is about the linemen, besides BMI, that contributes to this increased risk.

Although other research studies have found an association between cardiovascular disease and BMI (obesity), elevated BMI generally has not been as strong a risk factor as found in this study. This suggests to us that other factors, which we were not able to measure, could be contributing to the increased risk of cardiovascular disease among linemen. Some of the specific risk factors for cardiovascular disease which are associated with obesity include high blood pressure, decreased HDL cholesterol, and decreased glucose tolerance (diabetes). It has been suggested that anabolic

steroid use might be a risk factor for cardiovascular disease, but no information was available to us regarding their use by specific individuals or groups of players.

We did not have information on many of the established risk factors for cardiovascular disease including smoking history, blood pressure, and cholesterol levels. The respiratory disease rates, however, do not suggest that smoking in this population is any more prevalent than in the comparison U.S. population. Additionally, our information on BMI was limited to reported heights and weights during the last season played since we did not have information on changes in weight after the men left professional football.

Despite these limitations, this study shows that certain groups of football players are at an elevated risk for cardiovascular disease and should be encouraged to have regular medical check-ups. Appropriate control of cholesterol, blood pressure, and weight have been shown to effectively prevent cardiovascular deaths. This study provides additional evidence for the importance of obesity as a risk factor for heart disease, even among a group of professional athletes.

Finally, we would suggest that there be continued surveillance of this population. Further follow-up of mortality in approximately five years would be useful in resolving some issues, such as whether the observed increase in Hodgkin's disease and ALS occurred by chance.

We will be meeting with you and with representatives of the NFL in a few days and will explain these findings in more detail and will answer any questions. If you have any questions feel free to call either Sherry Baron at (513) 841-4386 or Robert Rinsky at 841-4400.

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#### References:

<sup>1</sup> Neft D, Cohen R, Korch R. The Sports Encyclopedia: Pro Football, St. Martin's Press, New York 1992.

<sup>2</sup> Steenland, K, Beaumont, J, Spaeth S, et. al., New developments in the life table analysis system of the National Institute for Occupational Safety and Health, JOM 32, 1990.

**Table 1**  
**Demographics of Study Population**  
**6,848 Professional Football Players**

<b>Race</b>		<b># Credited Seasons<sup>2</sup></b>	
White <sup>1</sup>	54%	1	17%
Non-white	46%	2	15%
<b>Year First Played</b>		3	10%
Before '60	4%	4	9%
'60-'64	6%	5-7	26%
'65-'69	9%	8-10	12%
'70-'74	16%	11+	9%
'75-'79	20%		
'80-'84	23%		
'85-'88	22%		

<sup>1</sup> Includes Hispanic

<sup>2</sup> Those playing prior to 1972 had at least 5 credited seasons

**Table 2**  
**Distribution of Deaths by Year**

<b>Year</b>	<b>Number</b>	<b>%</b>
Before '75	11	8%
'75-'79	17	12%
'80-'84	35	25%
'85-'91	76	55%
<b>Total</b>	<b>139</b>	<b>100%</b>

**Table 3 Standardized Mortality Ratios for Players with Five or More Credited Seasons- 1959-1988**

Cause of Death	Total			White			Non-White		
	#	SMR <sup>1</sup>	95% CI <sup>2</sup>	#	SMR	95% CI	#	SMR	95% CI
All Deaths	103	0.54*	0.44-0.66	69	0.63**	0.49-0.79	34	0.43**	0.30-0.60
All Cancer	24	0.81	0.52-1.21	17	0.79	0.46-1.27	7	0.88	0.35-1.82
Digestive	6	0.88	0.32-1.92	4	0.87	0.24-2.21	2	0.91	0.11-3.30
Respiratory	5	0.51	0.16-1.18	4	0.54	0.15-1.39	1	0.40	0.01-2.21
Urinary	2	1.83	0.22-6.59	1	1.15	0.03-6.37	1	4.48	0.11-24.89
Prostate	2	4.41	0.53-15.9	1	2.87	0.07-15.9	1	9.47	0.24-56.60
Heamatopoietic	5	1.23	0.40-2.87	4	1.33	0.36-3.41	1	0.94	0.02-5.23
Brain	3	1.50	0.41-5.84	2	1.59	0.19-5.73	1	4.13	0.10-22.94
All Other	1	0.18	0.00-1.01	1	0.25	0.00-1.39	0	0.00	0.00
Nervous System	5	1.89	0.61-4.42	3	2.00	0.41-1.20	2	1.75	0.21-6.30
Cardiovascular	34	0.87	0.60-1.22	23	0.83	0.53-1.25	11	0.95	0.47-1.79
Circulatory System	3	0.35	0.07-1.03	2	0.44	0.05-1.57	1	0.25	0.01-1.40
Respiratory System	1	0.15*	0.00-0.83	1	0.28	0.01-1.55	0	0.00	0.00
Digestive System	2	0.16**	0.02-0.59	1	0.15*	0.00-0.85	1	0.18	0.0-1.00
Accidents	20	0.61	0.37-0.94	16	0.80	0.46-1.27	4	0.31**	0.09-0.80
Violence	6	0.21**	0.07-0.45	2	0.16**	0.02-0.57	4	0.24**	0.07-0.62
All Other	8	0.28**	0.12-0.56	4	0.33*	0.09-0.84	4	0.25**	0.07-0.64

<sup>1</sup> Standardized Mortality Ratio    <sup>2</sup> 95% Confidence Interval \* Statistically significant p<.05    \*\* Statistically significant p<.01



**Table 4 Standardized Mortality Ratios for Players with Four or Fewer Credited Seasons- 1972-1988**

Cause of Death	Total			White			Non-White		
	#	SMR <sup>1</sup>	95% CI <sup>2</sup>	#	SMR	95% CI	#	SMR	95% CI
All Deaths	36	0.42**	0.30-0.59	15	0.47**	0.51-1.97	21	0.40**	0.24-0.60
All Cancer	6	1.14	0.42-2.89	4	1.50	0.41-3.83	2	0.78	0.09-2.80
Digestive	2	1.93	0.23-6.96	0	0.0	0.0	2	3.08	0.37-11.10
Respiratory	0	0.00	0.0	0	0.0	0.0	0	0.0	0.0
Urinary	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Prostate	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Heamatopoietic	1	0.68	0.02-3.75	1	1.24	0.03-6.90	0	0.0	0.0
Brain	1	2.28	0.06-12.69	1	3.42	0.09-19.07	0	0.0	0.0
All Other	2	1.40	0.16-5.09	2	2.40 <sup>1</sup>	0.27-8.70	0	0.0	0.0
Nervous System	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Cardiovascular	4	0.63	0.17-1.62	1	0.44	0.01-2.45	3	0.74	0.15-2.17
Circulatory System	1	0.45	0.01-2.50	0	0.0	0.0	1	0.64	0.02-3.56
Respiratory System	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Digestive System	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Accidents	13	0.56*	0.30-0.95	7	0.59	0.24-1.22	6	0.52	0.19-1.13
Violence	11	0.45**	0.23-0.81	2	0.28	0.03-1.01	9	0.53*	0.24-0.99
All Other	1	0.05**	0.00-0.28	1	0.19	0.00-1.06	0	0.0	0.0

<sup>1</sup> Standardized Mortality Ratio <sup>2</sup> 95% Confidence Interval <sup>3</sup> This elevation is due to one connective tissue cancer (SMR=11.26) which is not statistically significant

\* Statistically significant p<.05 \*\* Statistically significant p<.01

**Table 5**  
**Heights and Weights of Body Mass Index Categories**

Height	BMI of 28 Weight (lbs)	BMI of 32 Weight (lbs)
5' 11"	201	229
6' 0"	207	236
6' 1"	212	242
6' 2"	218	249
6' 3"	224	256

**Table 6**  
**Race and Body Mass Index Distribution for Players by Position Played**

Position Category	Race % White	Body Mass Index (%) <sup>*</sup>		
		<28	28-31	32+
Defensive/Offensive Linemen	69%	1%	35%	64%
Running Back, Line back, Tight End	49%	13%	79%	8%
Quarterback, Receiver, Kicker, Defensive Back, Special Teams	48%	85%	14%	1%
Total	54%	36%	41%	23%

<sup>\*</sup> Based on height and weight during last season played available for 94% of cohort

**Table 7**  
**Standardized Mortality Ratios for Players Stratified by Position**  
**Players with Five or More Credited Seasons 1959-1988**

<b>Offensive and Defensive Linemen</b>						
	Total		White		Non-White	
	#	SMR	#	SMR	#	SMR
All cardiovascular	32	1.15	25	1.18	7	1.05
Ischemic	21	0.98	20	1.16	1	0.25
hypertensive	2	1.68	1	1.92	1	1.50
Cardiomyopathy	6	3.54*	2	2.07	4	5.47*
<b>Running Backs, Tight Ends, and Linebackers</b>						
	Total		White		Non-White	
	#	SMR	#	SMR	#	SMR
All Cardiovascular	10	0.43**	5	0.35**	5	0.56
Ischemic	7	1.11	4	0.34*	3	0.55
Hypertensive	0	0.00	0	0.00	0	0.00
Cardiomyopathy	2	1.19	0	0.00	2	1.98
<b>Quarterbacks, Receivers, Defensive Backs, Kickers, Special Teams</b>						
	Total		White		Non-White	
	#	SMR	#	SMR	#	SMR
All Cardiovascular	12	0.43**	9	0.43*	3	0.29*
ischemic	11	0.53*	9	0.53*	2	0.31
hypertension	0	0.00	0	0.00	0	0.00
cardiomyopathy	0	0.00	0	0.00	0	0.00

\* Statistically significant p<.05    \*\* Statistically significant p<.01

**Table 8**  
**Cardiovascular Causes of Death**

<b>Cardiovascular Cause of Death</b>	<b>#</b>
Ischemic	25
Hypertensive	2
Arterial Sclerotic      Cardiovascular Disease*	3
Cardiomyopathy	4
Cardiomegaly	2
Dysrhythmia	1
Nonspecific	1
Total	38

\*In the 9th ICD revision (1978) this cause was removed from the Ischemic Heart Disease category

**Table 9**  
**Nested Case Control Conditional Logistic Regression Results**  
**All 37 Cardiovascular Deaths**

<b>Variable</b>	<b>Beta</b>	<b>SE<sup>1</sup></b>	<b>RR<sup>2</sup></b>	<b>CI<sup>3</sup></b>
<b>Model 1</b>				
Race (non-white)	0.54	0.28	1.7*	1.01-2.95
Body Mass Index <sup>4</sup>				
<28			1.00	
28-31	0.95	0.51	2.58	0.95-6.99
32+	1.80	0.54	6.04**	2.19-17.08
<b>Model 2</b>				
Race (non-white)	0.55	0.28	1.7*	1.01-2.98
Position Category				
Quarterback, Receiver, Kicker, Defensive Back, Special Teams			1.00	
Running Back, Lineback, Tight End	0.04	0.57	1.05	0.34-3.18
Offensive/Defensive Line	1.31	0.46	3.70**	1.51-9.07

<sup>1</sup> Standard Error    <sup>2</sup> Relative Risk    <sup>3</sup> 95% Confidence Interval    <sup>4</sup> BMI during the last season played

\* Statistically significant p<.05    \*\* Statistically significant p<.01