

Pectoralis Major Ruptures in the National Football League

Incidence, RTP, and Performance Analysis

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Background: While pectoralis major (PM) tears are rare injuries in National Football League (NFL) athletes (previous study reported only 10 PM ruptures between 2000 and 2010), the incidence of these injuries has increased over the past decade. The impact these injuries have on a player's performance after return has not been measured.

Purpose/Hypothesis: To identify player characteristics that may predispose to PM tears and to determine the impact of this injury on return to play and performance. We hypothesized that there would be no difference in performance between the year before and after their injury.

Study Design: Descriptive epidemiology study.

Methods: NFL players who experienced PM tears between the years 2010 and 2018 were identified using publicly available reports. Several individual player characteristics were identified and recorded, and the return-to-play rates after injury were determined for each position. The pre- and postinjury Pro Football Focus grades of players who met inclusion criteria were compared. A paired *t* test analysis of the change in player performance was used for analysis.

Results: In this study, 63 ruptures were identified between 2010 and 2018. Linebackers had the highest incidence of PM tear compared with any other position. Of all injuries, 79.3% were sustained by defensive players. The majority of PM tears occurred during games. Only 6.9% of players who sustained the injury were suspended for performance-enhancing drug use during their professional career. A total of 85.7% of players returned to play in the NFL after injury. Among those who returned to play there were no significant changes in player performance from pre- to post-injury.

Conclusion: NFL players demonstrated 85.7% return-to-play rates and no significant drop-off in performance after PM ruptures. During the time period studied, there was an increase in incidence of PM ruptures compared with the previous decade. Further investigation is needed to determine potential causes for the increased incidence of PM ruptures in NFL players.

Keywords: muscle injuries; National Football League; NFL; pec tears; pro football focus; football (American)

As in the general population, pectoralis major (PM) ruptures are a rare injury in National Football League (NFL) players. A previous study²¹ reported that only 10 complete ruptures occurred in the NFL between the years 2000 and 2010. However, over the last 20 years, PM injuries have become increasingly more common in both the general public and among NFL players.^{3,19} Evidence suggests that the increased incidence of these injuries among the general public may be related to the increased interest in weight training, especially bench-press training.³ In addition to the bench press, which has been associated with PM tears in 53% of military cadets⁴ and 80% of athletes,⁵ other factors that have been associated with PM ruptures

include older age and anabolic steroid use.^{4,5} Anabolic steroid use has been hypothesized to predispose individuals to PM tears because of disproportionate gains in maximal force production combined with a stiffer tendon that absorbs less energy and fails with less elongation.^{7,9}

While factors leading to an increase in PM tears among the general population have been suggested, the reason behind the surge in PM tears among NFL players is unknown. According to Haley and Zacchilli,⁷ the tendon typically tears during an eccentric contraction of the PM under heavy loads with the arm in extension and external rotation. These injuries are usually caused by either direct trauma, which ruptures of the muscle belly, or indirect trauma due to excessive muscle tension that leads to an avulsion of the humeral insertion or disruption at the musculotendinous junction.¹⁰ Two studies^{19,21} have confirmed that the trauma required to cause a PM rupture in an NFL

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player most commonly occurs during football play (either games or practice) rather than during weight lifting. More specifically, the most common mechanism for PM ruptures in NFL players was tackling an opponent.²¹

PM ruptures are a cause of missed time from play for NFL players. Although PM ruptures are not regarded as career-jeopardizing injuries, they are often season-ending injuries for NFL players that require surgery and rehabilitation before return. PM ruptures account for a mean of 130 days missed secondary to this injury.¹⁹ The number of missed days increases to 147 days if surgery is undertaken.¹⁹ While a recent meta-analysis²⁶ reported 74% of the athletes returned to play at the same level after PM tears, return to play (RTP) and performance have not been reported for NFL players returning to play after PM tears.

The purpose of this study was to identify individual player characteristics that may predispose athletes to PM injuries and report performance after return from PM injuries. We hypothesized that there would be no difference in performance in the year after the injury compared with the year of the injury.

METHODS

Season-ending PM ruptures sustained by NFL players during the years 2010-2018 were identified using publicly available injury reports, team statements, and news articles. Example sources used included but were not limited to ESPN.com, NFL.com, www.pro-football-reference.com, and team websites. For each of these injuries, the date, position played, age of player at time of injury, treatment, and situation in which the injury occurred were determined. Each player's ability to RTP in the NFL was determined.

To explain why these players sustained injuries, history of performance-enhancing drug (PED) suspensions and NFL Combine bench-press numbers were obtained for each player. The bench-press numbers were used as a proxy for each player's baseline bench-press strength. The performances of these players at the NFL Combine were recorded and compared with the performances of others at their position (ie, linebacker, defensive back, offensive lineman, etc). The database used for the NFL Combine analysis was MockDraftable.¹¹

From the entire list of players who returned to play, a smaller cohort was used to compare the performance before injury and after return. To be included in performance comparison, an athlete had to play at least 4 games in the season before injury and at least 4 games in the season after injury. This requirement was made to allow for adequate comparison and was used in previously published outcome

studies^{22,23} assessing performance after return from injury. Only the first PM rupture a player experienced in the NFL was included for the performance analysis. Those who sustained a second PM tear during the following season were excluded from analysis.

The Pro Football Focus (PFF) comprehensive grading system was used for all performance analysis in this study. This proprietary grading system was developed to quantify performance beyond statistics commonly reported. Each play of every game was graded by 2 independent PFF analysts. After watching each play, each analyst graded every player on the field using a scale of -2 to +2 according to the player's performance on each play. For example, a -2 for a quarterback would be a game-ending interception in a critical game, and a +2 would be a precise deep throw into a tight window in a critical game situation. A 0 grade indicated a play or plays that were expected to be made. Other examples for quarterbacks included a short pass that was completed (grade of +0.5) and a pass that should have been intercepted but was dropped by the defender (grade of -1.5). Once completed, the grades of the 2 independent analysts were compared by a senior analyst, who arbitrated any differences between the 2 grades. These grades were verified by the Pro Coach Network, a group of former and current NFL coaches. The individual play grades were used to compile a game grade for each player on the scale of 0 to 100. The game grades were used to compile an overall season grade, and they took into account a player's consistency and role. Each position was graded in a specific manner based on the responsibilities and expectations of that position. Players' full grading explanations can be found on the PFF website (www.PFF.com).¹⁴

The pre- and post-injury season PFF grades were recorded for each included player, and the player's performance change due to injury was calculated. The mean change in performance was calculated for each position that had multiple players who met the inclusion criteria. Mean change in performance was also calculated for teams on each side of the ball (offense and defense) and for all players. The change in performance was considered statistically significant at a $P < .05$.

RESULTS

Between the years 2010 and 2018, a total of 58 NFL players sustained at least 1 season-ending PM rupture. Two players sustained a right PM tear and then later tore the contralateral side. One player first tore the right side and later sustained another PM tear, but the side was not able to be publicly identified. One player also sustained 3

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Ethical approval was not sought for the present study.

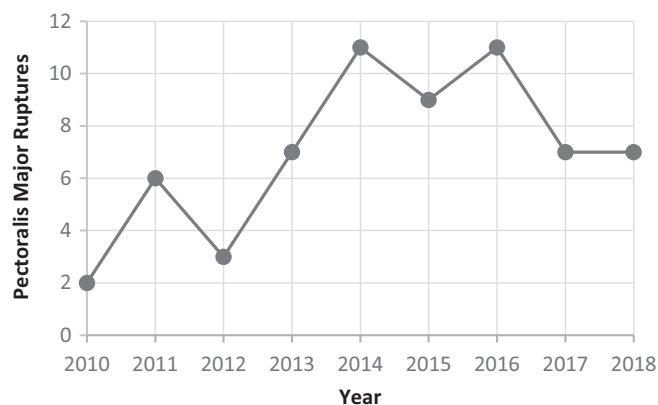


Figure 1. Number of pectoralis major ruptures by year, 2010-2018.

TABLE 1
Pectoralis Major Ruptures and Return to Play

Position	Players With Pectoralis Major Ruptures	Total Pectoralis Major Ruptures	Players Who Returned to Play, n (%)
Defensive lineman	14	14	11 (78.6)
Linebacker	21	25	23 (92.0)
Defensive back	12	13	10 (76.9)
Total defense	46	52	44 (84.6)
Offensive lineman	7	7	6 (85.7)
Tight end	1	1	1 (100)
Running back	2	2	2 (100)
Quarterback	1	1	1 (100)
Total offense	11	11	10 (90.9)
Total	58	63	54 (85.7)

separate PM ruptures (right, right, and then left). In total, 63 separate PM ruptures were identified. The number of PM ruptures for each year is shown in Figure 1. Of the players who sustained these injuries, 79.3% (46/58) were listed as defensive players. The individual position with the most players identified was linebacker, which accounted for 36.2% (21/58) of all players injured. The full positional breakdown can be found in Table 1. Those injured had a mean age of 26 ± 1 years of age at the time of injury and mean 4 ± 1 years of NFL experience before the injury. Of the injuries, 76.2% (48/63) occurred during a game, 11.1% (7/63) occurred in practice; 11.1% (7/63) occurred during training, lifting, or offseason activities; and 1.6% (1/63) occurred during warm-ups before a game.

When examining athletes at the NFL Combine who later ruptured their PM, they were in the $63^{\text{rd}} \pm 8$ mean percentile for bench press ($n = 35$) at their given position. When the NFL suspension records were examined, only 6.9% (4/58) of the players with a PM rupture had been suspended for PED use during their professional career.

After their injury, 53 players underwent surgery, while the specific treatment for 10 of the injuries was not determined. The players returned to play in the NFL at a rate of

TABLE 2
Performance of Players 1 Season Before and 1 Season After Injury^a

Position	PFF Grade, Mean \pm SD			P
	Preinjury	Postinjury	Difference	
Defensive lineman (n = 9)	68.22 \pm 4.78	68.18 \pm 8.05	-0.04 \pm 8.44	0.99
Linebacker (n = 13)	63.50 \pm 3.94	61.41 \pm 5.35	-2.08 \pm 5.89	0.50
Defensive back (n = 6)	63.27 \pm 7.54	64.78 \pm 7.69	1.52 \pm 6.97	0.69
Total defense (n = 28)	64.97 \pm 2.89	64.31 \pm 3.96	-0.66 \pm 4.02	0.75
Offensive lineman (n = 4)	74.40 \pm 7.98	72.33 \pm 7.15	-2.08 \pm 13.61	0.81
Total offense (n = 7)	65.63 \pm 9.90	68.17 \pm 7.30	2.54 \pm 8.71	0.61
Total (n = 35)	65.10 \pm 3.04	65.08 \pm 3.52	-0.02 \pm 3.68	0.99

^aPFF, Pro Football Focus.

85.7% (54/63). The RTP of each position can be seen in Table 1. Defensive backs had the lowest RTP rate of all positions (76.9%; 10/13).

The comparison of the PFF grades for the players who returned to play is shown in Table 2. This performance analysis demonstrated that regardless of position or the side of the ball they played (offense or defense), there was no statistically significant decrease in performance after a PM injury.

DISCUSSION

The incidence of PM major ruptures among NFL players has increased in recent years. Compared with a previous study²¹ that reported only 10 total PM ruptures occurring between 2000 and 2010 (0.91 per year), this study has found that 63 total PM ruptures occurred from 2010 to 2018 (7.0 per year). This data represents a staggering 769% increase in total PM ruptures and is consistent with a recent report.¹⁹ The increase in rate of PM ruptures among NFL players mirrors the overall increased incidence of PM ruptures identified in the general population.³

Several hypotheses have been suggested that explain the increase rate of PM tears in the general population. First, some attribute the rise in PM ruptures to the increased use of the bench press exercise associated with the popularization of health and fitness.^{3,6} During the bench press, the arm is abducted and externally rotated, causing the PM to be under maximum tension. When there is a sudden eccentric contraction of the PM, a PM rupture may occur.^{3,10} Second, PM ruptures have been associated with concomitant anabolic steroid use.³ Rates of anabolic steroid use associated with PM vary widely. At the extremes, de Castro Pochini⁵ reported that 86.7% of those with PM ruptures in their study used anabolic steroids, while none of the military academy athletes in the PM rupture study by Chan et al⁴ admitted to anabolic steroid use. Wolfe et al²⁵ and

Kakwani et al¹⁰ published self-reported rates of 33% and 23.1%, respectively, while Aärimaa et al¹ suspected that 36.3% of those in the PM rupture study used anabolic steroids.

However, these explanations may not completely explain the rise in PM ruptures seen in NFL players. First, unlike the general population, who are performing a bench press in up to 80% of the ruptures,⁵ only 11.1% of the PM ruptures among NFL players occurred during training, lifting, or offseason activities; the majority occurred during games. Second, with regard to a possible link with anabolic steroid use, only 4 of the 58 NFL players we identified with PM ruptures had PED suspensions during their professional career. Not all PED suspensions were necessarily related to anabolic steroid use. In addition to testing for exogenous sources of testosterone, the NFL tests for other substances, such as beta-2 agonists, selective androgenic receptor modulators, anti-estrogenic drugs, masking agents, and protein and peptide hormones (testing began in 2014), that have not been associated with tendon ruptures.¹³ Furthermore, there has been no evidence to suggest that anabolic steroid use is more prevalent among NFL players during this study period than the previous decade.

An increase in PM ruptures also does not appear to be related to changes in strength, size, and speed within the NFL player population. The mean strength, size, and speed of players at the NFL Combine has fluctuated from year to year, but they have not demonstrated a consistent increase/decrease that could be associated with this rise in PM ruptures. Additionally, the players who sustained the PM rupture were in the 63rd \pm 8 mean percentile for bench press at the NFL Combine. This means that they were close to average compared with peers at their positions, and below average strength or above average strength does not seem to predispose players to this injury.

Last, the increased incidence in PM ruptures among NFL players cannot be explained by a change in NFL player population. Since 2010, the total number of teams (32) has not changed, and the only change in roster size was growth of the practice squad from 8 to 10 players in 2014.¹⁶

Other potential causes that may merit further investigation include NFL rule changes, such as decreased practice time and those limiting helmet-to-helmet contact and below-the-waist and head contact during blocking, all implemented during the past decade. In 2011, under the new collective bargaining agreement, teams were no longer allowed to practice twice per day during the preseason, offseason programs were reduced, and the number of fully padded practices allowed during the season was also cut to reduce practice field head collisions.¹⁵ Fewer preseason practices for elite rugby players were associated with an increased odds of injury and percentage of games missed during the actual season.²² A study of elite Australian football players¹² demonstrated that a higher preseason load allowed players to develop the physical qualities needed for competition and reduced their injury risk during the season.

In addition to these NFL practice changes, rules were modified to limit potential head trauma. The new rules eliminate head-first launching and encourage defensive

players to tackle by wrapping their opponent below the head/neck area. While limiting head and neck trauma, this modification may expose tacklers to more PM injuries. In rugby, a sport that does not use helmets and has likely less launching, tackling is considered the most dangerous part of the game.^{17,2} Tackling techniques have been demonstrated to contribute to injury rates in this sport.^{17,2} A recent study¹⁸ of rugby players surmised that high tackling—that is, tackles made with the arm with the shoulder elevated coupled with horizontal abduction, contralateral trunk rotation, and an extended elbow—subjected tacklers to a higher potential for PM injury. In our study, defensive players accounted for 84.6% of PM ruptures. Linebackers, who record the most tackles of any position in the NFL,²⁰ were most vulnerable to PM ruptures.

Additionally, the rules for offensive players blocking players have been altered to prevent hits to the head and reduce contact below the waist on defensive players. This requires blockers to increasingly engage their opponents with their hands, arms, and shoulders instead of chop blocking (diving at) the legs or blindsiding their opponents.⁸ Blocking an opponent who is not directly in front of him forces a player to abduct and externally rotate his arm. This positioning with sudden eccentric contraction is a common mechanism of PM rupture.¹⁰ In our study, offensive linemen, excluding tight ends, accounted for 7 of the 11 (63.6%) PM ruptures that occurred among offensive players.

Despite the increase in PM ruptures, our study demonstrates that players who sustained this injury returned to play in the NFL at a high rate (85.7%) and at similar performance levels. While defensive players were slightly less likely to return than offensive players (RTP rates of 84.6% and 90.9% respectively), no position had a statistically significant change in PFF grade upon RTP. Overall, players demonstrated a nonsignificant PFF grade difference of -0.02 ± 3.68 after return. While we did not specifically quantify bench press strength after repair, Yu et al²⁶ demonstrated that 75% of athletes who have surgical PM repairs return to their preinjury strength.²⁶ Our metrics were also unable to precisely determine the amount of missed time from injury. Prior studies have reported that surgical repair allows for athletes to return to sport about 6 months after injury.^{21,26} Another study by Sahota et al¹⁹ reported that NFL players with PM ruptures treated operatively missed only 146.7 ± 55.0 days; those treated nonoperatively missed 77.2 ± 72.9 days.¹⁹

The current study has several limitations. First, the PM injuries were identified from publicly available sources rather than medical records. Because of this, the grade and type of rupture, exact mechanism of injury, possible concomitant injuries, and exact treatment are not known. In addition, it should be noted that while the cohort of players identified is considerable, not all players who sustained PM ruptures between the years 2010 and 2018 may have been identified. However, this method of acquiring data has been used to identify sports-related injuries in previously published studies.^{23,24} Second, the injury rate could not be normalized for each position since the number of players at each position on the roster can vary team to team and week

to week based on the needs and the offensive/defensive schemes desired. Certain positions also rotate players more throughout the game than others, which makes true normalization difficult. Third, the PFF grading system has not been previously used to assess NFL player performance in a peer-reviewed journal. However, the metrics used to gauge performance of players are limited by traditional statistics, such as tackles, interceptions, forced fumbles, yards gained, and so forth. PFF was selected because its grades allow the comparison of performance for all positions, even offensive linemen that are not evaluated with traditional statistics. Last, the number of players with a PM rupture at each position is relatively small and limits the power of the comparisons within groups. Despite this limitation, this study confirms that an increase in PM ruptures is occurring, and, to our knowledge, this study is the first to quantify RTP and performance changes in NFL players returning from PM ruptures.

CONCLUSION

Our analysis suggests the incidence of PM ruptures among NFL players has increased over the past decade. The majority of these injuries occurred during games (76.2%), and 79.3% of those injured were defensive players. After injury, 85.7% of all players returned to play. When they returned to the NFL, these players demonstrated no significant decrease in their PFF performance grades in the year of return. Further investigations are needed to determine the causes contributing to the increase in PM injuries in NFL players.

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