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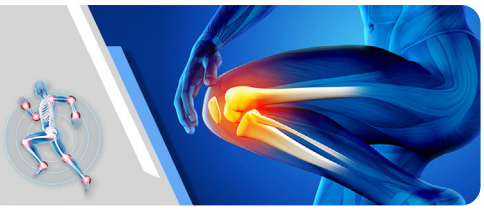
Research Article

JOURNAL OF ORTHOPAEDICS AND SPORTS MEDICINE

ISSN: 2688-5115



The Effect of Thursday Night Football on Injuries in the National Football League

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Abstract

Background: This study aimed to determine the relationship of recovery period length on overall injury patterns (rates and incidence) for athletes in the National Football League.

Methods: Official NFL gamebooks were queried from 2011 to 2015, and each in-game injury was analyzed for all regular season games. Data included athlete name, position, season, week, date, weekday, teams, and injured body part. ANOVA testing determined statistical significance of injury rates across weekdays, season weeks, and positions.

Results: A total of 27,712 injuries were analyzed. On average, 21.4 (8.6; 20.9-21.9) injuries were sustained per game on Sunday, 18.2 (6.9; 16.7-19.7) on Monday, and 21.7 (6.9; 20.2-23.3) on Thursday. The difference between Sunday and Thursday games was negligible (p=0.9264), while Monday games had fewer injuries than Sundays (p=0.0028) and Thursdays (p=0.0214). There was no difference in number of injuries each team sustained on Thursday compared to the week prior to (10.8 versus 10.8; p= 0.4971) or week after (10.8 versus 10.7; p=0.7315) its Thursday game. Among positions, defensive linemen (p=0.0036), linebackers (p=0.0297), skilled running positions (p=0.0099), and wide receivers (p=0.0259) sustained fewer injuries on Mondays compared to Sundays, but no statistical difference existed between Thursdays and Sundays.

Conclusion: Our analysis indicates that shortened recovery before Thursday games does not have significant effect on injury rates compared to Sunday games, while the additional rest day before Monday games correlates to fewer injuries. Additionally, there was no residual effect of reduced rest period affecting players' risk of injury the following week. A general trend of greater injury rates occurs as the season progresses; the incidence of injury during the final week of the season is nearly double that of the first. Interestingly, although injury rates did not differ among positions between Thursdays and Sundays, defensive positions and offensive ball-carrier positions saw reduced injuries on Mondays; this effect is likely secondary to the nature of their positions being most frequently involved in high-energy collisions during tackles.

Level of Evidence: III

Keywords: Football; Injuries; National Football League; In-game injury; Season games; ANOVA testing

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Citation: Akhil Sharma, Amanda N Fletcher, Jay K Shah, Craig C Akoh, Selene G. Parekh. The Effect of Thursday Night Football on Injuries in the National Football League. Journal of Orthopedics and Sports Medicine. 5 (2023): 304 - 310.

Received: June 23, 2023
Accepted: June 30, 2023
Published: July 05, 2023

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DOI:10.26502/josm.511500115

Introduction

The first record of professional football in America was in 1892 [1]. Today, the National Football League, or NFL, is the highest earning professional sports league in the world [2] – with a total revenue of nearly $17 billion in 2018 [3]. In 1970, the NFL introduced *Monday Night Football*, an extension of the league's original model of having games every Sunday [4]. This was well received, as players received an extra recovery day and the league profited. However, the introduction of *Thursday Night Football* in 2006 was met with less enthusiasm and remains a topic of controversy, as players and media personnel have been outspoken in their rebuke of the shortened recovery period [5]. Another change raising concern for player safety is the NFL's extension of the season by an additional week in 2021, to incorporate a seventeenth game during the regular season [6].

The debate on length of recovery and injury risk to athletes becomes especially relevant when considering the impact of professional football on players' health. NFL players suffer from increased neurodegenerative disease mortality compared to the general population [7]. A landmark study found over 99% of former NFL players had developed Chronic Traumatic Encephalopathy (CTE) by time of death [8]. NFL players also suffer from elevated all-cause mortality, including cardiovascular and neurologic etiologies, compared to athletes in Major League Baseball [7]. During NFL players' careers, the most common sites of injury are the ankle, shoulder, knee, spine, and hand [9]. Injuries amassed from careers in professional football also have indirect consequences, such as increased risk for opioid misuse that can develop into psychosocial issues [10].

The NFL has gradually accommodated the sport over the last 35 years to enhance safety in light of new research documenting player outcomes [11]. While this has led to significant changes, the economic and health merits of *Thursday Night Football* have been routinely weighed against each other since its advent and have resulted in a relative standstill due to a dearth of available evidence. For example, the NFL released data from the 2017 season, indicating that players averaged 6.9 injuries per Thursday game compared to 6.3 on other days [12]. While this data came with its own limitations, it was (and still is) one of the only sources of data on the topic of *Thursday Night Football* outcomes.

Consequently, players complained about the perceived correlation between Thursday games and greater injury risk, while the NFL refrained from denigration – claiming instead that this data was unsubstantial and that players benefited from the extended 10 day recovery period following Thursday night games [12]. Proponents of *Thursday Night Football* point at financial benefits – these games have "been especially beneficial for NFL teams in smaller media markets that do not consistently receive national broadcasting [5]."

Therefore, it becomes imperative to examine in greater depth the effects of shorter weeks during the NFL's regular season and the impact this has on player safety and health outcomes. The goal of this study is to determine the relationship between *Thursday Night Football* and subsequent risk of injury to players when compared to games played on Sunday and Monday.

Methods

For this descriptive epidemiological study, data was obtained from official NFL gamebooks queried by TheFantasyDoctors™ (Los Angeles, CA), a sports analytics platform offering research tools, fantasy sports league statistics, and projections for professional sporting leagues. Each in-game injury was analyzed for all regular season games across all 32 teams for five seasons (2011 to 2015). Exclusion criteria consisted of injuries occurring during the preseason (prior to Week 1) or postseason (after Week 17) and injuries sustained during the Bye Week. Descriptive data collected included athlete name, position, season, week, date of game, day of the week, teams playing, and injured body part.

To better understand injury patterns, positions were categorized into the following: quarterbacks; offensive linemen (offensive linemen, center, guard, left guard, right guard, tackle, offensive tackle, right tackle, left tackle); wide receivers; tight ends; skilled running positions (runningback, halfback, fullback); linebackers (inside linebacker, linebacker, outside linebacker); defensive backs (safety, strong safety, free safety, center back, defensive back); defensive linemen (defensive tackle, nose tackle, defensive end, defensive linemen); and special teams positions (kicker, kick returner, long snapper, punter, and others).

Statistical analysis:

Continuous variables were first analyzed for normality using histograms, box plots, and the Kolmogorov-Smirnov test. Homogeneity of variance was determined using the Levene test. Descriptive statistics were summarized using means, standard deviations (SD), and 95% confidence intervals (CI) for continuous variables reported as: mean (SD; lower limit CI - upper limit CI). Categorical variables were summarized with frequency and percentages. The primary outcome measure was the observed injury rates between Sunday, Monday, and Thursday night football games. One-way analysis of variance (ANOVA) tests were used to determine if injury rates differed across different days of the week (Sunday, Monday, Thursday), weeks of the season, and athlete positions. Nine position categories were analyzed, as outlined above. The season was divided into four quarters (weeks 1-4; weeks 5-9; weeks 10-13; weeks 14-17) for analyses. When ANOVA demonstrated a significant difference, the Tukey's HSD multiple comparison test was

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used to determine which groups were significantly different. An alpha level of $p < 0.05$ was used for statistical significance for all tests. All statistical analyses were performed using SAS, version 9.2 (Cary, North Carolina).

Results

42,953 NFL injuries were included in the database, occurring during the 2011 to 2015 seasons. Injuries sustained during pre- and post-season games were excluded (n=15,231), resulting in a total of 27,712 injuries for analysis. The NFL season consists of 256 games, where each team (32 total) plays 16 games during a 17-week period, allowing for one bye week per team. Thus, there were a total of 1,280 games for which player injury data was available. Table 1 demonstrates the distribution of weekday games per season.

Season

Injuries sustained per season are outlined in Table 2. There were 4467 (16.0%) injuries in 2011, 6841 (24.7%) in 2012, 5428 (19.6%) in 2013, 4937 (17.8%) in 2014, and 6010 (21.7%) in the 2015 season. The mean number of injuries per game was 17.6 (5.3; 16.9-18.2) in 2011, 25.3 (7.5; 24.4-26.2) in 2012, 20.7 (5.8; 20.0-21.4) in 2013, 23.5 (13.3; 21.8-25.1) in 2014, and 23.5 (13.3; 21.8-25.1) in 2015. When adjusting for multiple comparisons, the 2012 season had a higher injury rate compared to the 2011, 2013, and 2014 seasons (all $p < 0.0001$). The 2011 season had the least injuries sustained per game, significantly less than the 2012, 2013, and 2015 seasons (all $p<0.0001$).

Table 1: Number of games played per weekday.

Day	2011	2012	2013	2014	2015	Total
Sunday*	229	223	222	220	221	1115
Monday	17	16	17	18	17	85
Thursday**	10	17	17	18	18	80
Total	256	256	256	256	256	1280
Values in No. * Saturday games (n=14 in 2011; n=1 in 2012; n=2 in 2014; n=2 in 2015) were combined with Sunday ** One Wednesday game in 2012 was combined with Thursday						

Table 2: Injuries per season.

Season	Injury Frequency	Games per season	Average injuries per game
2011	4496 (16.2)	256	17.6 (5.3; 16.9-18.2)
2012	6841 (24.7)	256	25.3 (7.5; 24.4-26.2)
2013	5428 (19.6)	256	20.7 (5.8; 20.0-21.4)
2014	4937 (17.8)	256	18.8 (4.7;18.3-19.4)
2015	6010 (21.7)	256	23.5 (13.3; 21.8-25.1)
Total	*27712 (100)*	*1280*	*21.2 (8.4; 20.7-21.6)*
Values in No. (%) or mean (SD; lower limit CI-upper limit CI)			

Table 3: Injuries per weekday.

Day	Injury Frequency	Games	Average injuries per game
Sunday	24435 (88.2)	1115	21.4 (8.6; 20.9-21.9)
Monday	1541 (5.6)	85	18.2 (6.9; 16.7-19.7)
Thursday	1736 (6.3)	80	21.7 (6.9; 20.2-23.3)
Total/ Average	27712 (100.0)	1280	21.2 (8.4; 20.7-21.6)
Values in No. (%) or mean (SD; lower limit CI-upper limit CI)			

Weekday

The number of injuries per weekday across the five seasons are organized in Table 3. There was an average of 21.4 (8.6; 20.9-21.9) injuries per game sustained in the 1115 Sunday games, 18.2 (6.9; 16.7-19.7) injuries sustained per game in the 85 Monday games, and 21.7 (6.9; 20.2-23.3) injuries sustained per game in the 80 Thursday games. The injury rate was statistically different across weekdays (p=0.0037). When adjusting for multiple comparisons, Monday games resulted in fewer injuries than Sunday (p=0.0028) and Thursday (p=0.0214) games. The slightly higher injury rate for Thursday games compared to Sunday games (21.7 vs. 21.4) did not reach statistical significance (p=0.9264).

Season Week

Each NFL season consists of 17 weeks. Figure 1 displays the trend of injuries as the season progressed for all five seasons combined. Week 1 had the lowest injury rate (15.7; 6.0; 14.4-17.1), whereas Week 17 had the highest injury rate (31.1; 20.8; 26.5-35.8). The first (weeks 1-4), second (weeks 5-9), third (weeks 10-13), and fourth (weeks 14-17) quarters of the season had a mean of 18.5 (6.2; 17.8-19.2), 21.3 (6.1; 20.7-21.9), 21.6 (6.5; 20.9-22.4), and 23.2 (12.5; 21.9-24.6) injuries per game ($p <0.0001$) respectively. When adjusting for multiple comparisons, there were fewer injuries per game in the first quarter of the season (weeks 1-4) relative to all other quarters (all $p <0.0001$). Significantly more injuries were sustained per game in the last quarter (weeks 14-17) than the first ($p <0.0001$) and second (p=0.0140) quarters, but not the third (p=0.0768). Thus, there was a general trend of increasing injury rates as the season progressed, with the highest risk of injury occurring during the final four weeks.

Additionally, the average number of injuries each team recorded per Thursday night game was compared to the average number of injuries that the team recorded the week before and the week after its Thursday game. No difference was observed in the number of injuries each team sustained on Thursday compared to the week prior to (10.8 versus 10.8; p= 0.4971) or the week after (10.8 versus 10.7; p=0.7315) its Thursday game. The winning team of the Thursday game did report fewer injuries than the opponent (10.1 versus 11.5; p= 0.0493).

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DOI:10.26502/josm.511500115

Table 4: Injuries sustained by position.

		Sunday		Monday		Thursday		P-value*
Position	**All Injuries**	**Injuries**	**Injury Rate**	**Injuries**	**Injury Rate**	**Injuries**	**Injury rate**	
Defensive backs	5911 (21.3)	5247 (88.8)	4.5 (2.6; 4.4-4.7)	307 (5.2)	4.3 (2.1; 3.8-4.8)	357 (6.0)	4.8 (2.4; 4.3-5.3)	0.392
Defensive linemen	4001 (14.4)	3534 (88.3)	3.1 (2.1; 3.0-3.2)	219 (5.5)	2.4 (1.9; 2.0-2.8)	248 (6.2)	3.1 (1.9; 2.7-3.5)	0.0056**
Linebackers	4189 (15.1)	3707 (88.5)	3.2 (2.0; 3.1-3.4)	235 (5.6)	2.7 (2.0; 2.2-3.1)	247 (5.9)	3.2 (1.9;2.8-3.6)	0.0391***
Offensive Line	3591 (13.0)	3154 (87.8)	2.8 (1.9; 2.7-2.9)	214 (6.0)	2.4 (1.6; 2.0-2.7)	223 (6.2)	2.5 (1.6; 2.2-2.9)	0.1092
Quarterback	1063 (3.8)	944 (88.8)	0.8 (0.9; 0.8-0.9)	51 (4.8)	0.7 (0.9; 0.5-0.9)	68 (6.4)	1.1 (0.8;0.9-1.2)	0.0459****
Special (K, KR, LS, P, others)	412 (1.5)	363 (88.1)	0.3 (0.6; 0.3-0.4)	20 (4.9)	0.3 (0.5; 0.3-0.4)	29 (7.0)	0.3 (0.5; 0.1-0.4)	0.582
Skilled running positions	2843 (10.3)	2528 (88.9)	2.2 (1.5; 2.1-2.3)	142 (5.0)	1.7 (1.3;1.4-2.0)	173 (6.1)	2.3 (1.6;1.9-2.6)	0.0122*****
Tight End	1867 (6.7)	1672 (89.6)	1.4 (1.2; 1.4-1.5)	92 (4.9)	1.4 (1.1;1.2-.1.6)	103 (5.5)	1.5 (1.2 (1.2-1.8)	0.8443
Wide Receiver	3835 (13.8)	3389 (88.4)	3 (1.9;2.9-3.1)	211 (5.5)	2.4 (1.4; 2.1-2.7)	235 (6.1)	3 (1.8;2.6-3.4)	0.0330******
Total	27712 (100)	24538 (88.5)		1491 (5.4)		1683 (6.1)		

Values in No. (%) or mean (SD; lower limit CI-upper limit CI)
** P-values represent one-way ANOVATukey's Multiple Comparisons: Tests:*
***Defensive Linemen: Fewer injuries on Monday compared to Sunday (p=0.0036)*
****Linebackers: Fewer injuries on Monday compared to Sunday (p=0.0297)*
*****Quarterbacks: More injuries were sustained on Thursday however, this did not reach statistical significance compared to Monday (p=0.0559) or Sunday (p=0.0602) when adjusted for multiple comparisons*
****** Skilled Running Positions: Fewer injuries on Monday compared to Sunday (p=0.0099) and Thursday (p=0.0461)*
******* Wide Receivers: Fewer injuries on Monday compared to Sunday (p=0.0259)*

Injuries by Position

The majority of the injuries reported pertained to defensive backs (n=5911, 21.3%), linebackers (n=4189, 15.1%), and defensive linemen (n= 4001, 14.4%) (Table 4). Defensive linemen (p=0.0036), linebackers (p=0.0297), skilled running positions (p=0.0099), and wide receivers (p=0.0259) sustained fewer injuries during Monday games compared to Sundays. Skilled running positions also recorded fewer injuries on Monday games compared to Thursdays (p=0.0461). Quarterbacks were the only position showing a higher injury rate for Thursday games, with a mean of 1.1 injuries per game compared to 0.8 injuries during Sundays and 0.7 injuries during Mondays (p=0.0459). However, when adjusting for multiple comparisons using Tukey's, this no longer reached statistical significance for Monday (p=0.0559) or Sunday (p=0.0602).

Injured Body Part

Injuries grouped by anatomical region are outlined in Table 5. The most common sites involved the lower extremity, including 18.5% (n=5133) knee injuries, 13.3% (n=3671) ankle injuries, and 10.0% (n=2773) hamstring injuries. Shoulder injuries were the most common upper extremity injury reported, comprising 8.1% (n=2233) of total injuries.

Table 5: Frequency of injury by anatomical region.

Anatomical region injured	N	%
Abdomen	203	0.73
Achilles	143	0.52
Ankle	3671	13.25
Arm	123	0.44
Back	1118	4.03
Calf	756	2.73
Chest	239	0.86
Clavicle	53	0.19
Concussion	1314	4.74
Elbow	400	1.44
Face	73	0.26
Finger	512	1.85
Foot	1445	5.22
Forearm	68	0.25
Glute	15	0.05
Groin	1293	4.67
Hamstring	2773	10.01
Hand	443	1.6
Head	320	1.15

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DOI:10.26502/josm.511500115

Hip	779	2.81
Illness	746	2.69
Knee	5133	18.52
Leg	181	0.65
Miscellaneous	837	3.02
Neck	579	2.09
Pectoral	70	0.25
Pelvis/Tailbone	15	0.05
Quad	389	1.4
Rib	481	1.74
Shoulder	2233	8.06
Thigh NOS	486	1.75
Toe	555	2
Wrist	266	0.96
Total	27712	100
Values in No. (%)		

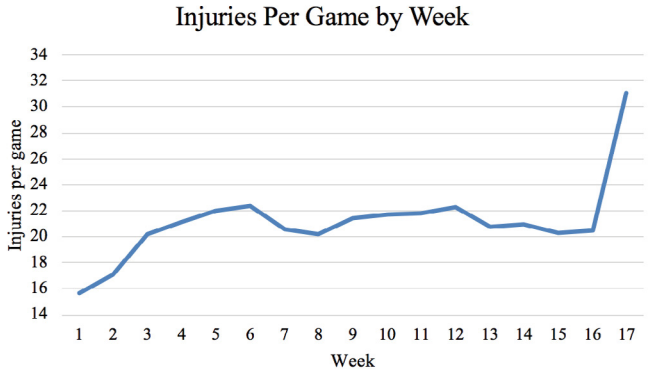

Figure 1: Aggregate of Injuries per Game by Week in the NFL, 2011-2015 seasons. As the season progresses, there is an increase in number of injuries sustained per game.

Discussion

Among professional leagues in the US, the NFL is the most violent, carrying rates of injury nearly five times greater than those of the National Basketball Association, National Hockey League, and Major League Baseball [13,14]. Accordingly, the NFL's institution of *Thursday Night Football* has been met with concern by opponents who claim that shorter rest leading up to the game poses a greater risk of injury to players. Therefore, we sought to assess the relationship between recovery period and injury patterns of NFL athletes. We found no difference between injury rates for games played on Thursday compared to Sunday, although Monday games saw significantly fewer injuries.

Prior studies on outcomes of *Thursday Night Football* have been limited by their inclusion criteria and endpoints of their research goals. Perez et al. [15] identified only those injuries that caused stoppage time during a game across four seasons [15]; Baker et al. [5] included a fifth season, but simply performed a head-to-head comparison of all-cause injury numbers between Thursday games and "weekend" (Sunday and Monday combined) games [5]. Both reports reviewed far fewer injuries than ours, at 2,846 and 9,621, respectively. This study is the first comprehensive assessment on the matter, which examined every reported injury for all five seasons and included four levels of subgroup stratification (weekday, season week, player position, and anatomical region).

Both aforementioned studies reported a decrease in injuries on games played on Thursday [5,15]. We found the opposite to be true; we saw a slight increase in the average number of injuries for Thursday games relative to Sunday, though this did not reach statistical significance. The most likely reason for this discrepancy lies in the power of our study. It is plausible that the previous authors would not have seen a statistical difference between Thursday and Sunday games if they had access to a greater number of injuries, or included injuries that did not cause game stoppage, at the time of analysis.

When evaluating by position, we observed that the majority of injuries throughout a season occurred among defensive positions (53.8%). This makes sense as defensive backs, linebackers, and defensive linemen are positions which require making high-energy collision contact with the player carrying the ball on the offensive side in order to stop progression of the football. Interestingly, when surveying which positions benefited most from reduced injury rates on Monday games, it is again those players involved most frequently in head-on collisions during tackles – defensive players (defensive linemen and linebackers) and offensive ball carriers (wide receivers and skilled running players). In contrast, we found that quarterbacks had a higher number of injuries on Thursdays compared to weekend games, but that this did not reach statistical significance. This finding was consistent with that of a previous study [15].

With regard to anatomical region of injury, our results were similar to many other studies on football injury data at the high school, collegiate, and professional level [16-20]. The most frequently injured body parts involved the lower extremity (41.8%) and the shoulder (8.1%). One explanation for this observation is that they correlate directly with the body parts impacted during a tackle. In a tackle, the defensive player often lowers the shoulder into the lower extremity of the offensive player carrying the football. Furthermore, we report that concussions and head injuries only comprised 5.9% of all injuries for the 2011 to 2015 seasons. This indicates that the NFL's implementation of policies to enhance player safety and their focus on improving concussion protocol appears to be working [21]. However, it is important to keep in mind

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that the data evaluated by this study was limited to reported injuries in official NFL gamebooks, which may introduce bias in terms of overreporting or underreporting of certain injuries.

Aside from number of injuries analyzed, a major strength of this study is that it is the first of its kind to perform a direct comparison of injuries each team sustained during the weeks directly before and after Thursday games. This allowed for greater context by which to interpret the significance of the aggregate finding that Thursday games did not have more injuries than Sunday games. The lack of difference in number of injuries a team faced on Thursday compared to the week prior to or the week after its Thursday game indicates that the shorter recovery period not only does not lead to greater injury risk – it also does not have a residual effect the following week. Our finding can be explained by what is currently known about the biodynamics of musculoskeletal injury, in that skeletal muscle rehabilitation can take as little as three days of rest to prevent stretching before more active use can be allowed without increasing risk of re-injury [22].

It is evident that the cumulative effect of multiple weeks have an adverse effect on player safety. While the last quarter of the season had significantly more injuries than the first and second quarters, the number of injuries sustained per game on Week 17 was nearly double the number of injuries seen on Week 1 (Figure 1). As NFL team owners have recently extended the season into an eighteenth week, we caution the negative effect that this would 206 foreseeably have on player safety based on the trend observed in this study [23].

We conclude that *Thursday Night Football* games do not pose greater injury risk than traditional Sunday games. However, on the basis of our findings, we recommend more education be provided to players on injury prevention regarding safer tackling techniques and greater emphasis be placed on strength and conditioning for defensive players. As Monday games routinely demonstrated lower injury rates, perhaps it would be beneficial to alternate Thursday and Sunday games with games on Monday the following week.

There were limitations to our study. Our analysis only covered injury data across five seasons. Additionally, as information was recorded by NFL officials in gamebooks, we must be wary of human error and the possibility of reporters being overzealous in recording what criteria constituted an injury for any particular game. Finally, our data subset was limited to the regular season. Future studies on injury trends in the NFL may focus on trends in the preseason and postseason to see what similarities and differences may arise. They may also decide to isolate players further by position and investigate the role of physical therapy and conditioning on injury rates.

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