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QUANTIFICATION OF ACCELEROMETER DERIVED IMPACTS ASSOCIATED WITH COMPETITIVE GAMES IN NCAA DIVISION I COLLEGE FOOTBALL PLAYERS

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ABSTRACT

The aims of the present study were to 1) examine positional impact profiles of NCAA division I college football players using global positioning system (GPS) and integrated accelerometry (IA) technology, and 2) determine if positional differences in impact profiles during competition exist within offensive and defensive teams. Thirty-three NCAA Division I Football Bowl Subdivision players were monitored using GPS and IA (GPSports, Canberra, Australia) during 12 regular season games throughout the 2014 season. Individual player datasets (n = 294) were divided into offensive and defensive teams, and positional sub-groups. The intensity, number, and distribution of impact forces experienced by players during competition were recorded. Positional differences were found for the distribution of impacts within offensive and defensive teams. Wide receivers (WR) sustained more very light and light to moderate (5-6.5 G force) impacts than other position groups, while the running backs (RB) were involved in more severe

(>10 G force) impacts than all offensive position groups, with the exception of the quarterbacks (QB) ($p<0.05$). The defensive back (DB) and linebacker (LB) groups were subject to more very light (5.0-6.0 G force) impacts, and the defensive tackle (DT) group sustained more heavy and very heavy (7.1-10 G force) impacts than other defensive positions ($p<0.05$). Data from the present study provide novel quantification of positional impact profiles related to the physical demands of college football games and highlight the need for position-specific monitoring and training in the preparation for the impact loads experienced during NCAA Division I football competition.

Key Words: Integrated Accelerometers, monitoring, American football

INTRODUCTION

American football is a field-based team-sport with competition characterized by repeated short-duration, high-intensity, intermittent movement patterns involving accelerations, decelerations, sprinting, and multi-directional running, followed by periods of low-intensity recovery and tactical strategizing between plays (10,29). In addition to the running demands associated with American football, athletes are exposed to frequent collisions and blunt force trauma associated with repeated contact with opponents and the ground during tackling, blocking, and ball-carrying activities (25). Previous research (10,24,29) has provided some insight into positional movement profiles, including the quantification of high-intensity accelerations and decelerations and sprint distances, along with a rudimentary understanding of exercise to rest ratios performed during National Collegiate Athletic Association (NCAA) division I football games. However, there is currently limited quantitative information describing the number and intensity of impacts associated with competitive NCAA division I football games. Due to the intense physical demands associated with American football competition, a quantitative examination of position-specific impact profiles may provide an increased understanding of the competitive demands for individuals participating in NCAA division I football games, and novel insight for performance coaches seeking to develop position-specific training and recovery strategies.

Advances in game analysis technologies, such as global positioning system (GPS) and integrated accelerometry (IA), have provided a valid and reliable means of assessing activity profiles (4,11,12,28) and an accurate measure of the impacts associated with collisions in contact team-sports (3,5,18,21). The quantification of competitive movement demands associated with American football (29) and collisions in team-sport competition similar in nature to American football, including rugby league (1,7,18,19,21,23), rugby sevens (9), Australian rules football (17,27,30), and rugby union (5,20) have been reported. Nevertheless, the unique characteristics of American football will dictate specific and distinct physical demands that require detailed examination.

The development of GPS technology with IA have allowed the physiological demands of practice and competition in contact team-sport to be quantified by the tracking of player movement demands (1,7,18,21,29,32). Integrated triaxial accelerometers have proven to be a reliable means of measuring physical activity across multiple players in team-sport (2), and offer a valid tool for detecting the frequency and magnitude of impacts and collisions associated with practice and competition in contact team-sport (6). Impacts may differ in magnitude depending on the intensity of movement undertaken by an athlete and commonly occur in collision sport as a result of decelerations, high-intensity changes in direction, landing from jumps, falling to the ground, and collisions and tackles inherit to collision sport similar to American football (18). While the use of movement profiles collected from GPS and IA offers an assessment of athlete movement during sport-specific activity, the use of impact data collected by GPS and IA during competition and training may provide the most holistic assessment of volume and intensity of exercise in comparison to the traditionally used movement metrics. As such, the quantification of the impact profiles in NCAA division I college football may add novel insight to the physical loading demands placed upon athletes during competition.

Within American football, each position group has specific physiological and movement demands associated with unique technical and tactical requirements (14). The positional movement profile characteristics associated with NCAA division I football games have been reported (29) and significant ($p < 0.05$) differences between positions groups on offense and defense for high-intensity movement demands have been established. Movement characteristics may provide a rudimentary understanding of the physical demands associated with competition, however, these measures fail to consider the physical demands associated with the contact nature of competitive football games. American football competition presents a unique model to study position-specific impact profiles that may be similar to other contact team-sports. The characteristics of repeated collisions and the associated blunt force trauma resulting from competition in Rugby League and Rugby Union players have been reported (3,5,18,21), and significant ($p<0.05$) inter-positional differences in total impacts experienced have been demonstrated during competition (20,26). However, uncertainty exists regarding the intensity and frequency of position-specific impact profiles of NCAA division I football players during competition. Despite the widespread inclusion of GPS and IA technology in collegiate American football programs, there remains a paucity of research regarding the characteristics of collisions experienced by players during competition. The accurate determination of impact forces experienced by players during games may provide sports performance specialists with novel insight into the position-specific demands of competition and highlight ways in which GPS and IA data can be used to optimize athlete performance programs.

The aims of the present study were to 1) examine the positional impact profiles of NCAA division I college football players associated with competitive game performance using IA technology, and 2) determine if positional differences in impact profiles exist within offensive and defensive teams. We hypothesized that significant positional differences will exist in the number and intensity of impacts associated with competitive performance in NCAA division I college football. Data obtained will provide information for performance coaches seeking to optimize position-specific training programs.

METHODS

EXPERIMENTAL APPROACH TO THE PROBLEM

To examine the positional impact characteristics during NCAA division I football games, portable accelerometer data were collected from players during 12 regular-season games. All games were 60 minutes in duration, comprised of four 15 minute quarters, each followed by a brief recovery period, and played outdoors between the hours of 12:00 and 21:00 over a period of thirteen weeks from September to November. All participants were required to participate in a minimum of 75% of the total offensive or defensive plays for the GPS and IA derived datasets to be included in the present study. Each individual GPS and IA dataset was characterized as constituting either offensive or defensive team performance, and subsequently divided into specific positional groups for the offense that included wide receivers (WR, 41 datasets), quarterbacks (QB, 12 datasets), running backs (RB, 41 datasets), tight ends (TE, 22 datasets), offensive linemen (OL, 37 datasets), and for the defense that included defensive backs (DB, 55 datasets), linebackers (LB, 36 datasets), defensive ends (DE, 33 datasets) and defensive tackles (DT, 17 datasets).

SUBJECTS

Thirty-three National Collegiate Athletic Association (NCAA) Division I Football Bowl Subdivision (FBS) football players (age 20.7 ± 1.0 years; height 188.6 ± 7.2 cm; and mass 106.7 ± 19.6 kg) participated in the present study. Positional anthropometric data are presented in Table 1. All subjects were collegiate athletes whom had been selected to participate in the football program eight months prior to the commencement of the study. All participants in the present study completed the teams' off-season physical development training program that included a full-body strength and power training program and specific skills and conditioning sessions designed to simulate the demands of NCAA division I college football competition. The present study comprises statistical analysis of data collected as part of the day to day student athlete monitoring and testing procedures within the university's football program. Researchers were provided with de-identified GPS and IA datasets from twelve regular season games for analysis. De-identified data included participant playing position for the purposes of position-specific data analysis. Ethical approval was obtained from the university's human research ethics committee.

Insert Table 1 Here

PROCEDURES

Global Positioning System Units. The present study used commercially available GPS receivers (SPI HPU, GPSports, Canberra, Australia) which operated in a non-differential mode at a sampling frequency of 15 Hz. The GPS receivers also contain integrated triaxial accelerometers (IA), which operated at 100 Hz and assessed the frequency and magnitude of full-body acceleration ($m \cdot second^{-2}$) in three dimensions, namely, anterior-posterior, mediolateral, and vertical (16,21). Impacts were derived from the vector of the X-Y-Z axes of the triaxial accelerometer and calculated as the square root of the sum of the squares of each axis, whereby 27.7 G was the maximum accelerometry output (8). Subjects had previously worn GPS and IA receivers in outdoor training sessions that included football-specific running, and skill-related and game-simulated contact activities during a three-week pre-season training period. Prior to the commencement of each game, GPS receivers were placed outside for 15 minutes to acquire a satellite signal, after which, receivers were placed in a custom designed pocket attached to the shoulder pads of the subjects. Shoulder pads were custom-fit for each individual, thereby minimizing movement of the pads during games. The GPS and IA receivers used in the present study (66 g; 74 mm x 42 mm x 16 mm) were positioned in the center of the upper back, slightly superior to the scapulae. Subjects were outfitted with the same GPS receiver for each of the twelve games. Following the completion of games, GPS receivers were removed from the shoulder pads, and subsequently downloaded to a computer for analysis utilizing commercially available software (Team AMS, GPSports, Canberra, Australia). The GPS and IA receivers used in the present study have demonstrated both inter- and intra-accelerometer reliability (CV = 1.87 – 2.21%) (13), while similar integrated accelerometers have been validated for quantifying the number and intensity of collisions in Rugby League (6) and measuring peak impacts in team-sport (CV = 4.8%, filtered at cut-off frequency of 12Hz) (31).

Data provided from IA were assessed as impact profile variables including very light, light to moderate, moderate to heavy, heavy, very heavy, and severe impacts. Classifications of parameters of impact profile variables are described below and presented in Table 2. Each of the GPS and IA derived variables measured in the present study were calculated using commercially available software (Team AMS, GPSports, Canberra, Australia). The impact classification system utilized in the present study was based on methods previously described in Rugby League (18,21), Rugby Union (3,5,20) and manufacturer recommendations (GPSports, Canberra, Australia). GPSports reports peak accelerations, irrespective of the nature of the peaks, from which impact forces can be calculated, given the fact that acceleration is proportional to force if mass is constant (32).

Impact Classification System. Player exposure to impact was determined via accelerometer data provided in ‘G’ force. A classification system within Team AMS (GPSports, Canberra, Australia) software allows for six zones of impact to be preset and used for subsequent analysis. Zone one is indicative of the lowest intensity of impact, with each zone progressively categorizing impact intensity to zone six, reflecting the highest impact and intensity of movement. Each impact classification was coded as one of six intensities of impact (Table 2). Very light impacts such as accelerations, decelerations, and changes of direction were considered to be 5.0 - 6.0 G. Light to moderate impacts, such as minor collisions with other players and contact with the ground, were considered to be 6.1 – 6.5 G. Moderate to heavy impacts resulting from physical contact with the opposition at moderate velocities were considered 6.6 – 7.0 G. Heavy impacts from high-intensity collisions were classified as 7.1 – 8.0 G, while very heavy impacts resulting from high-intensity collisions and high velocities were classified as 8.1 – 10.0 G, and severe impacts resulting from high-intensity collisions between players traveling at high velocities, were classified as those exceeding 10 G.

Insert Table 2 Here

STATISTICAL ANALYSES

All movement variables from the present study were presented as descriptive statistics, mean ± standard deviation (SD). Hypothesis testing was conducted to determine any main effects for impact profile data between position groups on the offensive and defensive teams. A one-way ANOVA was used to determine positional group main effects. In the event homogeneity of variance assumption was violated, a Welch Robust Test of Equality was used to determine main effects between position groups. For all main effects detected by a one-way ANOVA, post-hoc Bonferroni tests were utilized. Alpha intervals for all hypothesis testing were set at $p < 0.05$. To determine the magnitude of main effects and interactions, partial eta-square (n^2) effect size statistics were adopted, which indicate the percentage of variance accounted for by the effect, with values of 0.01 – 0.06, 0.06 – 0.15, and > 0.15 considered small, moderate, and large, respectively. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS for Windows, version 14.0; SPSS, Inc., Chicago, IL. USA).

RESULTS

Offense: Significant ($p<0.001$) main effects from ANOVA testing were reported for all impact profile variables measured in the present study for the offensive position groups (Table 3). Post-hoc analysis of impact profile variables, revealed significant ($p<0.05$) inter-position differences across all impact zones, with the exception of zone 5. The WR position group sustained significantly ($p<0.001$) more very light (zone 1) impacts than all other offensive position groups, while the OL position group underwent significantly ($p<0.01$) more very light impacts than RB and QB position groups. Analysis of light to moderate impacts (zone 2) demonstrated a significantly ($p<0.001$) greater number of impacts for WR than all other offensive position groups. Similarly, both TE and OL position groups underwent significantly ($p<0.01$) more light to moderate impacts than RB and QB position groups. The number of moderate to heavy (zone 3) impacts sustained during games were similar among WR, TE, and OL position groups, and significantly ($p<0.001$) greater than both QB and RB position groups. The WR and OL position groups experienced significantly ($p<0.001$) more heavy (zone 4) impacts than both the RB and QB position groups. Analysis of very heavy (zone 5) impacts revealed no significant ($p<0.05$) inter-position differences, while the number of severe (zone 6) impacts was significantly ($p<0.05$) greater for the RB position group than the WR, TE, and OL position groups. Finally, the QB position group sustained significantly more severe (zone 6) impacts than the TE position groups.

Defense: Significant ($p<0.001$) main effects from ANOVA testing were reported for all impact profile zones measured in the present study for the defensive position groups, with the exception of zone 2 impacts (Table 4). Post-hoc analysis of impact profile variables, revealed significant ($p<0.05$) inter-position differences across all impact zones, with the exception of zone 2 and zone 6. The DB position group sustained significantly ($p<0.001$) more very light (zone 1) impacts than the DT and DE position groups, while the LB group was involved in significantly ($p<0.001$) more very light impacts than the DT position group. The DT position group was involved in significantly ($p<0.001$) more moderate to heavy (zone 3), heavy (zone 4), and very heavy (zone 5) impacts than all other defensive position groups, while the DE position group sustained significantly more ($p<0.01$) heavy and very heavy impacts than the DB position group. The DT position group was involved in more light to moderate (zone 2) impacts than all other defensive position groups, while the DE position group engaged in more severe (zone 6) impacts than any other defensive group, however none of the inter-position differences within either of these impact zones reached a level of significance ($p<0.05$).

DISCUSSION

The present study examined the impact profiles associated with competitive games in NCAA division I college football players using portable IA technology, and assessed differences in positional groups within offensive and defensive teams. The results of the present study provide novel insight into the competitive demands experienced by NCAA division I college football players, and may provide scope for the design of position-specific and game-specific physical preparation strategies for coaches seeking to optimize training for the demands of competition. Results from the present study confirm our hypothesis that significant ($p<0.05$) differences in the number and intensity of impacts associated with competition exist between playing positions in NCAA division I college football players. The most notable findings for competitive game impact profile characteristics of offensive position groups were the WR position group undergoing more zone 1 and 2 (very light and light to moderate) impacts than all other offensive position groups, while the WR and OL group participated in more zone 3 and 4 (moderate to heavy and heavy) impacts than the RB group. The RB position group recorded the greatest number of severe impacts throughout the course of competition, which may reflect the characteristic high-velocity collisions with defenders associated with the positional demands of being the primary offensive ball carrier. Defensively, the DB and LB position groups were involved in more zone 1 impacts than all other position groups. The DT group participated in more zone 3, 4, and 5 (moderate to heavy, heavy, and very heavy) impacts than all other defensive position groups, which may be attributed to the physical demands of the DT position, often involving physical contact with numerous offensive players on each play throughout the course of competition.

Comparing the findings of the present study with the existing knowledge of positional game demands is problematic due to the lack of research on impact profiles in American football players. Positional analysis in contact team-sport similar to American football, including Rugby League (18,21) and Rugby Union (3,5,20,26), have demonstrated inter-positional differences in the quantity and intensity of impacts associated with competition, supporting the findings of the present study. Although the influence of the number and intensity of impacts sustained during competition on the duration of post-game recovery in Rugby League players has been investigated (18,21), and the biochemical and endocrine responses to competitive games in American football and Rugby league players have been reported (15,22), there is a lack of research quantifying the relationship between the physical demands of competition and the time-course of recovery associated with college football games. Accordingly, there is a need to establish the relationship between the physical demands of games, including movement and impact profiles, and the subsequent duration of recovery in NCAA division I football players, to provide insight into the effects of competition on athlete recovery.

The present study found significant ($p<0.05$) inter-position differences in the number of impacts encountered during competitive NCAA division I football games. The WR position group was involved in significantly ($p<0.001$) more zone 1 impacts than all other offensive position groups. Similarly, on defense, the DB position group recorded significantly ($p<0.001$) more zone 1 impacts than both the DT and DE position groups, while the LB group recorded significantly ($p<0.001$) more than the DT position group. The manufacturer (GPSports, Canberra, Australia) of the GPS and IA receivers used in the present study have indicated that low-intensity impacts (2.0-6.0G) are commonly attributed to walking and running, and thus a large amount of very light impacts may be a reflection of running volume throughout the course of competition (8). Additionally, high-intensity changes of direction, falling to the ground, landing from jumps, blocking, collisions, and tackles are all capable of eliciting high-intensity impacts (8).   Significant ($p<0.05$) inter-position differences in running volumes in NCAA division I players participating in competitive games have been demonstrated (29). Wellman et. al. (29) examined movement profiles associated with competitive games in NCAA division I football players and reported the WR group covered significantly ($p<0.05$) more total distance than all other offensive position groups, while the DB and LB position groups covered significantly ($p<0.05$) more total distance than both DT and DE position groups. The results of Wellman et. al. (29) support the findings of the present study, indicating the increased number of very light impacts detected in the WR and DB position groups may be attributed to the increased running volumes experienced as a result of the unique position-specific demands of these groups. Positional alignment at the commencement of each play that provides greater distance from the placement of the football gives these athletes a larger area for movement, providing increased movement requirements during plays. Additionally, the WR and DB cover more distance between plays as they are required to jog back to the line of scrimmage at the conclusion of plays, which may be a distance of 20-30 m to either huddle or re-assume their alignment for subsequent play, while other positions characteristically walk short distances during recovery between plays (24).

Offensively, the WR and OL position groups sustained significantly ($p<0.05$) more zone 2, 3, and 4 impacts than the RB and QB groups. While no significant inter-position differences were demonstrated with respect to very heavy impacts, the RB position group was involved in significantly ($p<0.05$) more zone 6 (severe) impacts than all offensive position groups, with the exception of the QB position group. These findings are substantiated by previous descriptions of the nature of severe impacts in contact team-sport (21). McLellan et. al. (21) described severe impacts as being indicative of high-intensity collisions with the opponent, making a direct front-on tackle on an opponent traveling at a high velocity, or being tackled by multiple opponents while running at maximal velocity. The RB position is primarily responsible for carrying the football on running plays and catching the ball on short passing plays, in addition to blocking DT, DE, and LB on passing plays which require protection of the QB. The responsibility of running with the football at high velocities lends itself to direct blunt force trauma, often from multiple opponents, and supports the findings of the present study which indicated an increased number of severe impacts when compared to other offensive positions. Defensively, there were no significant differences between position groups with respect to light to moderate impacts, however the DT group registered significantly ($p<0.05$) more zone 3, 4, and 5 impacts than all other defensive position groups. Additionally, the DE position group was involved in significantly ($p<0.05$) more zone 4 and 5 impacts than the DB group. The greater number of zone 4 and 5 impacts demonstrated within the DT and DE position groups may result from the position-specific demands of these position groups, including rapid accelerations at the commencement of each play, followed by contact with the opposing offensive player, and the subsequent pursuit and tackling of the ball carrier.

Inter-positional differences in impact profiles resulting from Rugby Union competition revealed significant ($p<0.05$) differences between forwards and backs which is consistent with the findings of the present study for offensive and defensive positions (20,26). The significant differences in zone 1-4 impact counts between the WR and OL group when compared to the RB and QB group highlight distinct physiological impact characteristics associated with competition, which may require different training and recovery protocols to achieve optimal performance. The positional differences in the present study may be explained by the position-specific requirements of these individuals. Additionally, the tactics of the offensive team employed during games, namely the number of running and passing plays undertaken, may affect the positional impact distribution. During NCAA division I football games, the WR group is involved in significantly ($p<0.05$) more maximal acceleration and deceleration efforts than all other offensive position groups (29), likely resulting from the frequent changes of direction due to repeated route running. Additionally, the WR group is responsible for blocking the opposition on running plays and is involved in impacts resulting from physical collisions associated with carrying the ball following a reception on passing plays. The

OL position group engages in physical contact with the opposition on nearly every play, with the intensity and quantity of impacts presumably dictated largely by offensive strategy. Running plays typically require the OL group to quickly accelerate forward or laterally from a stationary position, initiate contact with the opposition, and move the defender thereby creating a running lane for the ball carrier. Passing plays involve the OL group moving backward or laterally in attempt to protect the QB, while waiting for the opposition to initiate contact. The RB group was involved in significantly ($p<0.05$) more severe impacts than all other offensive position groups with the exception of the QB group. These findings are likely the result of impacts with opponents, and subsequent impact with the ground, resulting from carrying the ball during running plays. The lack of a significant difference in the number of severe impacts between the RB and QB position groups may be due to offensive strategy. On plays involving the QB as the ball carrier, increased opportunity exists for multiple impacts with the opposition, and similarly, as the number of passing attempts increases, there is greater possibility of the QB being sacked or knocked down.

Defensively, while no significant inter-positional differences were observed for light to moderate impacts, significant ($p<0.05$) differences were demonstrated in the number of zone 3, 4, and 5 impacts between the DT group and all other defensive position groups. Characteristically, players in the DT position group accelerate short distances and perform rapid change of direction movements before engaging individual or multiple OL, followed by accelerating to pursue and tackle the ball carrier. The DB group initiates play further from the line of scrimmage and is primarily responsible for defending the

WR on passing plays and provides secondary support on running plays, thereby limiting the amount of physical contact with the opposition. The LB group characteristically commences play 4-5 m from the line of scrimmage and is generally responsible for providing support on running plays, in addition to defending TE and RB on passing plays. Due to the increased responsibilities in defending running plays within the position-specific responsibilities of the LB group compared to the DB group, and a closer alignment to the line of scrimmage at the initiation of play, the opportunity for physical contact with offensive players is increased. The present study indicated a larger number of zone 4 and 5 impacts for the LB group when compared to the DB group, although these results did not reach significance. Aligning directly on the line of scrimmage prior to the commencement of each play provides opportunity for the DT position group to be involved in physical contact from multiple players on every play, which is indicated in the present study with significantly ($p<0.05$) more zone 3, 4, and 5 impacts recorded for the DT group than all other defensive positions. In similar contact team-sport, significant ($p<0.05$) correlations have been demonstrated between the number of high-intensity (>7G) impacts sustained and post-match neuromuscular performance decrements and markers of skeletal muscle damage (18,21). As such, the accurate monitoring and prudent modification of practice impact loads of position groups involved in significantly more zone 4-6 impacts during competition may enhance recovery and improve subsequent competitive performance.

Significant inter-position differences in the intensity and distribution of impacts associated with NCAA division I college football competition exist. The greater number of zone 1 and 2 impacts for the WR, DB, and LB groups may be attributed to the significant differences in competitive game running volumes, including accelerations and decelerations, between position groups previously demonstrated (29). The position-specific physicality required of the OL group presumably resulted in more zone 3 and 4 impacts, while the significant differences in severe impacts of the RB position group compared to other offensive groups may result from high-intensity collisions from direct tackles at high-velocities, or being tackled by multiple opposing players, as described in investigations of impacts associated with Rugby League competition (18,21). The starting position of the DT group upon commencement of each play, along with rapid changes of direction and physical contact with multiple opponents which generally characterizes DT positional demands, resulted in more zone 3, 4, and 5 impacts than all other defensive position groups. Collectively, the results of the present study highlight distinct impact profiles for offensive and defensive teams, which may require the development of position-specific training and recovery protocols.

The results of the present study provide novel insight into the impact profiles of NCAA division I college football games and provide physical performance staff with quantified information. The present study demonstrated substantial differences in positional impact profiles associated with NCAA division I football games, emphasizing the importance of position-specific training to appropriately prepare players for the rigors of competition.

PRACTICAL APPLICATIONS

The present study provided a novel analysis of the number and intensity of impacts associated with NCAA division I college football games. The findings of this study suggest that repeated high-intensity impacts during NCAA division I football games are position specific in nature and support the use of position-specific training in the preparation of NCAA division I college football players for competitive games. Data from the present study augment our understanding of the competitive demands experienced by NCAA division I college football players, and provide scope for position-specific training strategies for performance coaches seeking to optimize competitive performance.

Maximizing performance and mitigating the effects of fatigue present unique challenges to performance coaches, and consequently, quantifying the physical demands associated with weekly practice and competition is critical. In contact team-sport similar to American football, the number of impacts exceeding 7 G has been significantly correlated with decreases in neuromuscular performance following competition (18). During the in-season period judicious monitoring, and the subsequent alterations of weekly practice and conditioning loads of individuals within position groups involved in large numbers of impacts, particularly those registering as heavy, very heavy, and severe, may reduce fatigue, expedite recovery, and improve competitive performance. As such, the DT, OL, and WR position groups may benefit from position-specific, and perhaps, individually prescribed practice loads. Because the OL and DT position groups often compete against one another in practice, limiting the number of live contact drills and scrimmage situations may result in a reduction of intense impacts sustained during the course of a practice week, possibly enhancing recovery and improving subsequent performance. Limiting the amount of contact the WR position sustains in practice sessions is common in American football, and this rationale is substantiated by the present study. Given the significant quantity of severe impacts sustained by the RB position, performance coaches should monitor, and in some cases, reduce the impact load of individual practice sessions by limiting the number of scrimmage situations the RB group is involved in. Data obtained from the study contribute new insight into the competitive demands of NCAA division I college football and provide a foundation from which to implement a systematic approach to the development of individual and position-specific training prescriptions. During the pre-season practice period, monitoring and periodizing training loads based upon position-specific impact profiles may allow performance specialists to scale the intensity of practices to better prepare athletes for forces encountered during competition.

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