International Journal of Strength and Conditioning

Smith-Hale, V., Mendoza, R., Vargo, C., Sabourin, J., Rider, B., Martin, J., Moore, W., & Hew-Butler, T. (2026). Positional Differences in American Football Players Internal Load and Recovery Over a 10-Week In-Season.
International Journal of Strength and Conditioning
https://doi.org/10.47206/ijsc.v6i1.549

# Positional Differences in American Football Players' Internal Load and Recovery Over a 10-Week In-Season

Valerie Smith-Hale[1]*, Ruben Mendoza[2], Cody Vargo[2], Jordan Sabourin[1,3], Brian Rider[4], Jeffrey Martin[1], Whitney Moore[1,5] and Tamara Hew-Butler[1,6]

*[1]Department of Kinesiology, Wayne State University, Detroit, MI, USA; [2]Department of Athletics, Wayne State University, Detroit, MI, USA; [3]Detroit Pistons Organization, Detroit, MI, USA; [4]Department of Kinesiology, Hope College, Holland, MI, USA; [5]Department of Kinesiology, East Carolina University, Greenville, NC, USA; [6]Nutrition and Food Science Department, Wayne State University, Detroit, MI, USA*

**Corresponding Author: valeriegeorgia12@gmail.com*

## ABSTRACT

Internal load metrics may better reflect the increased metabolic demands of American football linemen, not fully appreciated using external load metrics alone. This pilot study served to investigate both (1) internal workload and (2) autonomic nervous system (ANS) recovery using heart rate (HR) metrics in 28 collegiate football players, subdivided into three player position groups: BIG (linemen; n=20), COMBO (quarterbacks, linebackers, and tight ends; n=3), and SKILL (receivers and running backs; n=5) players. HR data were collected using chest-strap monitors (Firstbeat™) worn during the first two practices of each week, over a 10-week season. Internal load was assessed using training impulse (TRIMP) while ANS recovery was measured, pre-practice, using heart rate variability (HRV). Kruskal-Wallis non-parametric tests were used to compare the overall differences between the three player position groups. For internal load, TRIMP was statistically different between groups, $H(2)=23.25$, $p=0.001$. TRIMP values for BIG, COMBO, and SKILL were: 135.0±61.0AU, 123.0±50.8AU, and 101.0±53.1AU. Post-hoc pairwise comparisons revealed the only significant TRIMP difference was between the BIG group and the SKILL group ($p=0.001$). For ANS recovery metrics, HRV pairwise comparisons showed significant differences between BIG (53.4±25.2ms) and SKILL (72.6±30.5ms) position groups ($p=0.001$). These data suggest that BIG position group players may experience significantly greater internal loads and demonstrate the least ANS recovery, compared with SKILL players, across midweek practice sessions. These high metabolic loads may help explain why linemen are at greatest risk for heatstroke during practice.

**Keywords:** Linemen, TRIMP, Heart Rate Variability, Resting Heart Rate.

## INTRODUCTION

American football players are often grouped into three distinct "position" groups according to specific physical and performance characteristics such as strength, power, fitness, body mass, and game demands (1). Offensive and defensive linemen make up the subgroup of football players collectively referred to as the "BIG" group. BIG group players typically have the largest mass, greatest strength, and lowest total running demands (2, 3). The subgroup of football players commonly referred to as the "SKILL" group is made up of defensive backs and wide receivers. The SKILL group players typically accumulate the greatest total running demands (3) and have the least amount of body fat (2). As such, a global positioning system (GPS) analysis of 12 in-game competitions confirmed that linemen players covered less total distance (3,314.0 m) compared with non-linemen players (4,141.3 m) (3). Lastly, the subgroup of football players referred to as the "COMBO" group are comprised of quarterbacks, running backs, linebackers, and tight ends. The COMBO group players share common physical attributes and physical demands

IUSCA International Universities Strength and Conditioning Association

Copyright: © 2026 by the authors. Licensee IUSCA, London, UK. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/ 4.0/).

characteristic of players from both the BIG and SKILL groups (2).

Previous research suggests that the rate at which each subgroup of athletes recovers from training, varies (4, 5). For example, BIG group players demonstrate the lowest cardiac-autonomic recovery (assessed using the natural logarithm of the root mean square of successive differences/ LnRMSSD which measures vagally-mediated heart rate variability/HRV) between in-season practices when compared to SKILL and COMBO players (4). This finding appears counter-intuitive, from an external load measurement perspective, as BIG players demonstrate the lowest external workloads (389.8±47.0AU) compared with SKILL (523.9±76.9AU) and COMBO (444.7±74.8AU) players, as assessed using the PlayerLoad™ system (an external workload parameter which includes running, jumping, change of direction and body contacts and expressed in arbitrary units/AU) (4).

As such, most of the research examining football player workload measures "external" load which is defined as the physical work performed by athletes during training (6, 7). Most external load measurements use GPS systems which quantify physical outcomes such as distance, acceleration, speed and power (6). Alternatively, the term "internal" load reflects the body's psychophysiological response to multiple stressors – in addition to the applied external load - encountered during training (6, 7). Internal load is typically quantified using heart rate (HR) monitors or session ratings of perceived effort (sRPE) (8). As HR increases with increasing exercise intensity, other external and internal factors (i.e., extreme temperatures, illness, mental stress, fatigue etc.) may amplify the HR response to modest training loads (6, 9). Thus, internal load measurement encompasses the cumulative (internal plus external) stressors which impact training adaptations, functional outcomes, athlete health and performance (6).

For running-intensive sports, the relationship between PlayerLoad™ (external load) versus session RPE (internal load) metrics are robust (r = 0.49-0.84)(9). However, since linemen players perform the least amount of running of all player position groups, measurement of internal load may help explain why BIG players have the lowest cardio-autonomic recovery metrics despite travelling the least amount of distance during both practice (4) and games (3). Furthermore, from a health and safety perspective, the increased total and fat mass of BIG players elicits higher core temperatures (compared with non-linemen players) putting linemen at greatest risk for heat illness (4). Accordingly, data collected between 1998 to 2018 demonstrate that 97% of all exertional heatstroke (EHS) deaths in football players occur in linemen (10) with 100% of deaths occurring during supervised football practice (11).

The primary aim of this pilot investigation was to compare both internal load and autonomic nervous system (ANS) recovery, using HR-derived metrics, between BIG, SKILL, and COMBO subgroups of collegiate American football players during a 10-week competitive season. We hypothesized that BIG group players would demonstrate the highest internal load and lowest ANS recovery scores. More speculatively, this confirmation would help explain why linemen are at greatest risk for EHS and support internal load measurement in BIG players during football practice (10).

## METHODS

### *Subjects*

All participants were members of a National Collegiate Athletic Association Division-II (NCAA DII) football team (N=28), whose data were collected as part of the football team's customary training and monitoring protocol. The 28 participants who wore HR monitors throughout the season were selected by the football coaching staff. For post-hoc statistical analyses, the participants were sub-divided into three distinct player position groups: BIG (n=20), COMBO (n=3), SKILL (n=5) (Table 1). An Institutional Review Board, from a Midwestern university, reviewed the current protocol, and acknowledged that these data qualified as Exempt, according to Category 4 (use of existing, de-identified, data; no written informed signed consent required; IRB-21-01-3125-B3 EXEMPT approval on 02/22/2021).

### *Procedures*

#### *Training Schedule*

Game-days (GD) were on Saturday, with light practice on Sundays and off-days on Monday. Data were collected on Tuesdays (GD-4) and Wednesdays (GD-3) during the 10-week football season. We chose these two days because

Copyright: © 2026 by the authors. Licensee IUSCA, London, UK. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/ 4.0/).

Tuesday practices were designed, by the coaching staff, to be the most intense training days with regards to both total training duration and intensity as documented in prior "in-season" football studies (4, 12). Each training practice day lasted 145±15 minutes and began with the initiation of the organized warm-up (lead by the strength and conditioning coach) and ended with the head football coach's final whistle. Although we did not specifically quantify the duration of the warm-up (calisthenics plus stretching) within our total reported practice time, commencement of the warm-up remained a consistent starting point for us. Additionally, the warm-up remained standardized (same Strength and Conditioning coach, same routine) throughout the 10-week season.

*Demographic and Anthropometric Assessments*

After height and weight were measured, whole body composition (lean, fat, and bone mass) was assessed during August training camp, using a Hologic™ Horizon A (Marlborough, MA, USA) dual energy x-ray absorptiometry (DXA) scanner (TBAR1209 NHANES BCA calibration, software version 5.6.0.5). All scans were performed and analyzed by a single operator, with total body composition measurements including the head region. Athletes were instructed to refrain from exercise, food and fluid intake for four hours prior to the DXA scan.

*Internal Training Load*

Internal training load was quantified using radiotelemetry (Firstbeat Team, Firstbeat HR plastic belt, Jyväskylä, Finland) using pre-assigned chest-strap HR monitors (Firstbeat™, software version 2.8.1, Jyväskylä, Finland), which were also used to measure recovery. Each chest strap HR monitor used radiotelemetry signals to display HR in real-time, with a sampling rate of 125 Hz with an accuracy of RR-interval detection of 2 milliseconds (13). Our primary outcome variable, for measuring internal training load, was training impulse or "TRIMP". This parameter is calculated by the FirstbeatTM software version 2.8.1, using the HR reserve method and reported in arbitrary units (AU) (14).

*ANS Recovery Assessments*

Within 60-90 minutes prior to the start of each midweek practice, each participant presented to the weightroom and fastened a pre-assigned HR monitor around their chest and wore the same HR monitor for the duration of data collection. All HR metrics were individualized according to each player's demographic information (Table 1) and HR data. Once a HR reading was confirmed, each subject lay on the ground, quietly in a supine position, for three-minutes to assess recovery prior to practice. Caffeine and stimulant use were not controlled for in this assessment. The two primary outcome variables used to assess ANS recovery were heart rate variability (HRV) and resting heart rate (RHR). HRV represented the average root mean square of the successive difference (rMSSD) value in milliseconds (ms), while RHR represented the lowest HR recorded during the 3-minute rest period in beats-per-minute (bpm).

*Statistical Analyses*

Data normality was not confirmed via Shapiro-Wilk tests ($p<0.05$) for any HR-derived parameter. Therefore, non-parametric tests were used to complete the statistical analysis for HR variables. A Wilcoxon signed rank test was used to detect differences between Tuesday and Wednesday practices. A Kruskal-Wallis test was used to assess differences between BIG, COMBO, and SKILL position groups. If overall significance was found between position groups, a post-hoc comparison with adjusted p-values were used. Lastly, Cohen's d effect sizes were calculated to explore the meaningfulness in difference between groups. Effect Sizes (ES) were interpreted as follows: <0.2, trivial; 0.2-0.59, small; 0.6-1.19, moderate; 1.2-1.9, large; and >2.0, very large (15). Statistical procedures were carried out using IBM SPSS Statistics for Macintosh, Version 26.0 (Armonk, NY, USA) Statistical significance was set at $p\leq0.05$ and all data reported as mean±SD unless otherwise noted.

## RESULTS

Demographic and anthropometric data for the combined cohort, and separated by player position groups, are reported in Table 1. We chose to standardize body composition outputs by reporting body fat mass as body fat percentage (%) and bone mass as bone mineral density (BMD in g/cm$^2$). Between group differences were seen for age ($F=4.51$; $R^2=0.26$; $p=0.02$), bodyweight ($F=36.28$; $R^2=0.74$; $p<0.001$), body mass index/BMI ($F=22.76$; $R^2=0.65$; $p<0.001$), and body fat% ($F=70.32$; $R^2=0.85$; $p<0.001$) whereas BIG group players were significantly younger, heavier, and had higher

Copyright: © 2026 by the authors. Licensee IUSCA, London, UK. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/ 4.0/).

**Table 1.** Demographic (age, height, weight, and BMI) and body composition (fat, lean, and bone) results subdivided into the three player position groups (BIG, COMBO, and SKILL positions) and for the total cohort (N=28). All results expressed as mean±SD. BMI = body mass index; BMD = bone mineral density. *$p$<0.05; **$p$<0.01 for 1-way ANOVA between position groups.

| | Age (years) | Height (m) | Weight (kg) | BMI (kg/m²) | Body Fat (%) | Lean Mass (kg) | BMD (g/cm²) |
|---|---|---|---|---|---|---|---|
| BIG (n = 20) | 19.5±1.6* | 1.87±0.04 | 126.5±11.3** | 36.1±3.7** | 30.7±3.5** | 81.4±14.1 | 1.36±0.09 |
| COMBO (n = 3) | 21.7±1.3 | 1.84±0.04 | 95.5±7.4 | 28.0±3.3 | 19.7±1.2 | 73.6±5.3 | 1.43±0.06 |
| SKILL (n = 5) | 21.2±1.2 | 1.84±0.05 | 87.6±6.9 | 25.7±1.5 | 18.8±1.9 | 68.0±4.8 | 1.43±0.07 |
| TOTAL (N = 28) | 20.0±1.7 | 1.86±0.05 | 116.2±19.3 | 33.3±5.5 | 27.4±6.1 | 78.2±13.3 | 1.37±0.09 |

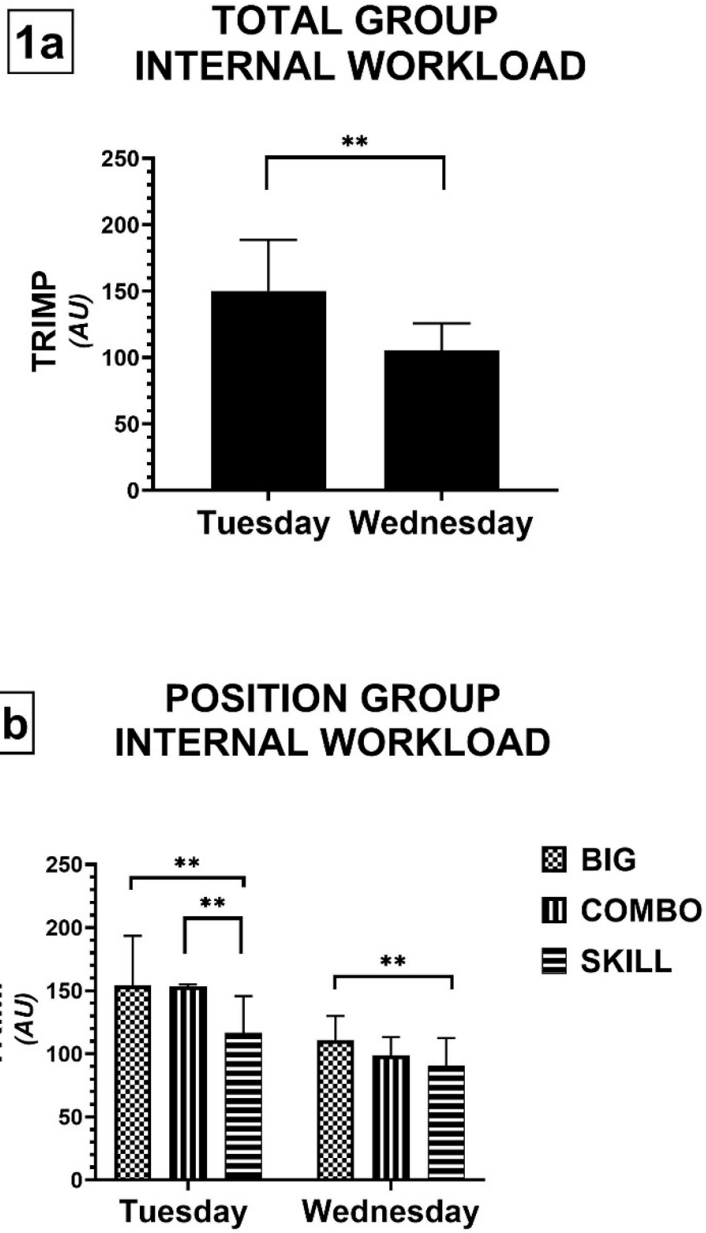



**Figure 1.** The 10-week average internal workload values assessed using heart rate-derived training impulse (TRIMP) measurement for both the Tuesday and Wednesday football practice sessions for both the total group combined (N=28; Figure 1a) and subdivided into the BIG (n=20), COMBO (n=3), and SKILL (n=5) player position groups (Figure 1b). All results expressed as mean±SD. AU = Arbitrary Units. *$p$≤0.05; **$p$≤0.01

Copyright: © 2026 by the authors. Licensee IUSCA, London, UK. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/ 4.0/).

percentages of body fat than COMBO and SKILL players. No significant group differences were seen for height ($p$=0.24), lean mass ($p$=0.10), or BMD ($p$=0.17).

Figure 1 details comparisons between Tuesday versus Wednesday practices for internal load, represented by TRIMP scores. When data from all three positional groups (N=28) were combined (Figure 1a), significant differences were noted in TRIMP (internal load) between Tuesday and Wednesday practice loads. Furthermore, when split into position groups (Figure 1b), significant differences were noted between BIG versus SKILL, and COMBO position groups on Tuesday and between BIG versus SKILL groups on Wednesday.

Across all twenty practices (Tuesday plus Wednesday data combined), the combined TRIMP values for BIG, COMBO, and SKILL were 135.0±61.0AU, 123.0±50.8AU, and 101.0±53.1AU, respectively. These combined TRIMP scores were statistically different between groups, $H(2)=23.25$, $p<0.001$. Post-hoc pairwise comparisons, with adjusted p-values, revealed that only the BIG's TRIMP scores were significantly greater than SKILL's ($p<0.001$; ES=0.42, small).

Figure 2 details comparisons between Tuesday and Wednesday practices for our two chosen recovery metrics, HRV (Figure 2a and 2b) and RHR (Figures 2c and 2d). When data from all three positional groups were combined, an overall significant difference was noted in HRV between Tuesday and Wednesday (Figure 2a). Post hoc comparisons revealed significant differences between BIG versus SKILL, and COMBO position groups on Tuesday, and between BIG versus SKILL groups on Wednesday (Figure 2b). For RHR, there was an overall significant difference between RHR on Tuesday and Wednesday (Figure 2c). Post hoc comparison for Tuesday and Wednesday revealed that BIG group players had a significantly greater RHR than both the SKILL and COMBO groups (Figure 2d).

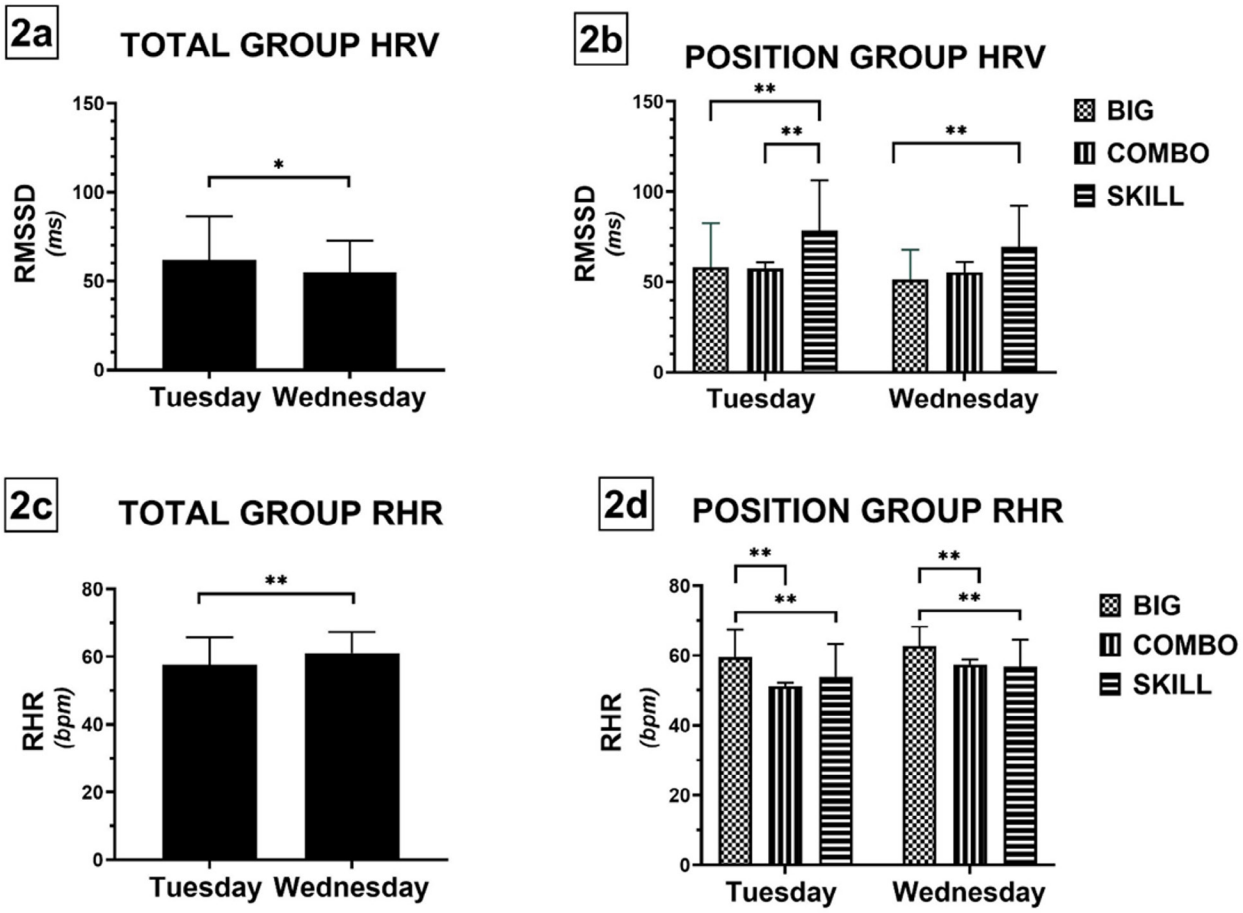



**Figure 2.** The 10-week average recovery metrics for both the Tuesday and Wednesday football practice sessions for both the total group combined (N=28; Figures 2a and 2c) and subdivided into the BIG (n=20), COMBO (n=3), and SKILL (n=5) player position groups (Figures 2b and 2d). Recovery was assessed using both heart rate variability (HRV), assessed using the root mean square successive differences (RMSSD) in Figures 2a and 2b (where the higher the RMSSD the higher the recovery) and resting heart rate (RHR) in Figures 2c and 2d (whereas the lower the RHR, the higher the recovery). All results expressed as mean±SD. *$p\leq0.05$; **$p\leq0.01$

Copyright: © 2026 by the authors. Licensee IUSCA, London, UK. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/ 4.0/).

Across all twenty practices (Tuesday plus Wednesday data combined), both recovery parameters demonstrated statistically significant differences between position groups for both HRV $H(2)=30.6$ms, $p<0.01$ and RHR $H(2)=53.4$bpm, $p<0.01$ using the Kruskal-Wallis test. Post-hoc pairwise comparisons for HRV showed significant differences between BIG (53.4±25.2ms) and SKILL (72.6±30.5ms) position groups ($p<0.01$; ES = -0.21, trivial). For RHR, significant differences were seen between the BIG position group (65.0±48.6bpm) and both the COMBO (53.3±5.1bpm) ($p<0.01$; ES=0.89, moderate) and SKILL (54.8±9.1bpm) ($p<0.01$; ES=0.69, moderate) groups.

## DISCUSSION

The primary aim of this investigation was to compare internal load and cardiac-autonomic recovery, using HR metrics, between three subgroups of American football players across a 10-week competitive season. These data cautiously suggest that BIG football players may experience the highest internal loads (i.e., highest TRIMP scores) and lowest ANS recovery scores, compared with SKILL and COMBO group players. BIG group players were also the heaviest players with the greatest amounts of lean and body fat percentage compared with SKILL and COMBO players (Table 1). This combination of persistently high metabolic loads coupled with a “heat stroke habitus” (i.e., high metabolic heat generation with reduced capacity for heat dissipation) provides a physiological rationale for why linemen may be at greatest risk for EHS (10). However, the small numbers of SKILL (n=5) and COMBO (n=3) players limit the strength of these conclusions.

To assess cardiac-autonomic recovery, a lower RHR (16) and higher HRV (17) value suggests enhanced physiological recovery from training stress (18). Accordingly, our BIG players had the highest RHR and lowest HRV, compared with players in the COMBO and SKILL groups, suggesting that the linemen players may be the least recovered athletes during mid-season practices, possibly due to the higher internal loads sustained during practice. These internal load data may physiologically explain the seemingly paradoxical findings obtained by Flatt et al 2020 whereas BIG players were the least recovered despite having the lowest external load values (non-normalized data) (4).

Studies which directly compare internal versus external load metrics in football players during practice, largely show a lack of association between internal versus external load parameters (19). Other studies demonstrate that accelerometers (external load) are not predictive of either internal load or ANS recovery (20). Collectively, it appears that the workload of linemen are not adequately captured using GPS units alone (21). Thus, we recommend that internal load, or a combination of internal plus external load measurements, be used for a more holistic evaluation of allostatic load and recovery in football players.

The main limitations of this preliminary study were the small and unequal sample size distribution and high variability within HRV measures which limit the strength of these conclusions. As such, future studies should target larger sample sizes and measure both internal and external loads. Additionally, the inclusion of core temperature measurements may validate hypothetical relationships between workload and heat illness, as speculated.

In conclusion, linemen football players sustain the highest internal loads compared with non-linemen players during in-season football practice. American football performance coaches should thereby consider incorporating HR-based metrics into load monitoring systems for BIG players. We speculate that real-time HR monitoring may assist on-field practitioners recognize severe cardiovascular strain which may, in turn, reduce the incidence of EHS in linemen while training outdoors in a warming world (22).

## CONFLICTS OF INTEREST

The authors have no conflict of interest to declare.

## FUNDING

No funding was received for this study.

## ETHICAL APPROVAL

An Institutional Review Board, from a Midwestern university, reviewed the current protocol, and acknowledged that these data qualified as Exempt, according to Category 4 (use of existing, de-identified, data; no written informed signed consent required; IRB-21-01-3125-B3 EXEMPT approval on

Copyright: © 2026 by the authors. Licensee IUSCA, London, UK. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/ 4.0/).

02/22/2021).

## DATES OF REFERENCE

Submission - 11/04/2025
Acceptance - 09/05/2026
Publication - 23/10/2026

## REFERENCES

1. Hoffman JR. The applied physiology of American football. Int J Sports Physiol Perform. 2008;3(3):387–92.
2. Hoffman JR. The Science of American Football 1st ed. New York: Routledge, Taylor and Francis Group; 15 November 2020.
3. Wellman AD, Coad SC, Goulet GC, McLellan CP. Quantification of Competitive Game Demands of NCAA Division I College Football Players Using Global Positioning Systems. J Strength Cond Res. 2016;30(1):11–9.
4. Flatt AA, Esco MR, Allen JR, Robinson JB, Bragg A, Keith CM, et al. Cardiac-Autonomic Responses to In-Season Training Among Division-1 College Football Players. J Strength Cond Res. 2020;34(6):1649–56.
5. Flatt AA, Esco MR, Allen JR, Robinson JB, Earley RL, Fedewa MV, et al. Heart Rate Variability and Training Load Among National Collegiate Athletic Association Division 1 College Football Players Throughout Spring Camp. J Strength Cond Res. 2018;32(11):3127–34.
6. Impellizzeri FM, Marcora SM, Coutts AJ. Internal and External Training Load: 15 Years On. Int J Sports Physiol Perform. 2019;14(2):270–3.
7. Jeffries AC, Marcora SM, Coutts AJ, Wallace L, McCall A, Impellizzeri FM. Development of a Revised Conceptual Framework of Physical Training for Use in Research and Practice. Sports Med. 2022;52(4):709–24.
8. Inoue A, Dos Santos Bunn P, do Carmo EC, Lattari E, da Silva EB. Internal Training Load Perceived by Athletes and Planned by Coaches: A Systematic Review and Meta-Analysis. Sports Med Open. 2022;8(1):35.
9. Helwig J, Diels J, Röll M, Mahler H, Gollhofer A, Roecker K, et al. Relationships between External, Wearable Sensor-Based, and Internal Parameters: A Systematic Review. Sensors (Basel). 2023;23(2).
10. Anderson SA, Eichner ER, Bennett S, Boden BP, Colgate B, Courson R, et al. Preventing Exertional Heat Stroke in Football: Time for a Paradigm Shift. Sports Health. 2025;17(3):484–90.
11. Boden BP, Fine KM, Spencer TA, Breit I, Anderson SA. Nontraumatic Exertional Fatalities in Football Players, Part 2: Excess in Conditioning Kills. Orthop J Sports Med. 2020;8(8):2325967120943491.
12. Wellman AD, Coad SC, Flynn PJ, Siam TK, McLellan CP. Comparison of Preseason and In-Season Practice and Game Loads in National Collegiate Athletic Association Division I Football Players. J Strength Cond Res. 2019;33(4):1020–7.
13. Parak J, Salonen M, Myllymäki T, Korhonen I. Comparison of Heart Rate Monitoring Accuracy between Chest Strap and Vest during Physical Training and Implications on Training Decisions. Sensors (Basel). 2021;21(24).
14. Firstbeat Technologies Oy. What is TRIMP? How Sports Teams Use It to Optimize Training. https://www.firstbeat.com/en/blog/what-is-trimp/ Accessed 16/01/2026.
15. Cohen J. Statistical Power Analysis for the Behavioral Sciences - Second Edition. Hillsdale, New Jersey: Lawrence Erlbaum Associates Inc; 1988; vol 12 p13.
16. Buchheit M. Monitoring training status with HR measures: do all roads lead to Rome? Front Physiol. 2014;5:73.
17. Plews DJ, Laursen PB, Stanley J, Kilding AE, Buchheit M. Training adaptation and heart rate variability in elite endurance athletes: opening the door to effective monitoring. Sports Med. 2013;43(9):773–81.
18. Thorpe RT, Atkinson G, Drust B, Gregson W. Monitoring Fatigue Status in Elite Team-Sport Athletes: Implications for Practice. Int J Sports Physiol Perform. 2017;12(Suppl 2):S227–S34.
19. Sobolewski EJ. The Relationships between Internal and External Load Measures for Division I College Football Practice. Sports (Basel). 2020;8(12).
20. Renaghan E, Wittels HL, Wittels SH, Wishon MJ, Hecocks D, Wittels ED, et al. Internal or External Training Load Metrics: Which Is Best for Tracking Autonomic Nervous System Recovery and Function in Collegiate American Football? J Funct Morphol Kinesiol. 2023;9(1).
21. Johnston RJ, Watsford ML, Kelly SJ, Pine MJ, Spurrs RW. Validity and interunit reliability of 10 Hz and 15 Hz GPS units for assessing athlete movement demands. J Strength Cond Res. 2014;28(6):1649–55.
22. Ebi KL, Capon A, Berry P, Broderick C, de Dear R, Havenith G, et al. Hot weather and heat extremes: health risks. Lancet. 2021;398(10301):698–708.

Copyright: © 2026 by the authors. Licensee IUSCA, London, UK. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/ 4.0/).