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Practice Versus Game External Load Measures in Starters and Non-Starters of a Men's Collegiate Soccer Team

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ABSTRACT

The purpose of the current study was to investigate differences in game versus practice external load between starters and non-starters of a men's collegiate soccer team during the early in-season play. In the first 2 weeks of the competitive season, National Collegiate Athletic Association Division I soccer athletes (n=19; mean±SD, age: 20.3±0.9 yr; body mass: 77.9±6.8kg; body height: 178.87±7.18cm; body fat: 10.0±5.0%; VO_{2max}: 65.39±7.61mL/kg/min) wore a global positional system device (GPS) during practices (n=8) and games (n=3). Starters were classified as players who maintained a minimum playing time of 45 minutes per game (n=10); other players (< 45 minutes of playing time per game) were considered non-starters (n=9). External load metrics collected were: total distance (TD), player load (PL), high-speed distance (HSD, >13 mph (5.8 m/s)), high inertial movement analysis (IMA, >3.5m/s^2), and repeated high intensity efforts (RHIE). Multivariate and repeated measures analyses of variance assessed differences in external load measures for practices and games in starters and non-starters. For starters and non-starters, TD, PL, HSD, IMA, and RHIEs were lower in practices compared to games ((25-25% of game loads, p<0.001). Therefore, practice did not simulate game volumes or intensities. An individualized approach to monitoring is recommended to ensure starters receive adequate recovery and non-starters receive exposure to game-load physical stress.

Keywords: GPS, athlete monitoring, athlete wellness, sport science

INTRODUCTION

Performance enhancement, a primary goal of training for sport, is often accomplished through manipulation of key training principles, such as variations in training volume and intensity, which will directly impact training program design. An important consideration in the program design is a quantification of the physical work performed by an athlete during training sessions and competitions, which is referred to as external load. Monitoring external training loads via global positioning software (GPS) devices allows practitioners to identify the impact of training and to individualize periodization and performance optimization strategies [1,2].
Soccer is an intermittent and high-intensity sport in which players are exposed to high volumes (e.g., total distance, player load) and intensities (e.g., high-speed running, sprints, tackles, jumps, change of direction, accelerations, decelerations) [3,4]. These physical demands, often defined via external load

monitoring, may result in accumulated fatigue, which may provide insightful data regarding physiological parameters related to risk of injury and training adaptation [5]. Soccer practices must fluctuate between high and low external training loads to prepare for competition and facilitate recovery [6]. Based upon the loads measured during competitive games, coaches are able to quantify game segments and compare practice drills in an attempt to match training intensity and volumes to competition [6]. Thus, external loads should be properly managed, as extreme volumes (i.e. total distance, body load) and intensities (i.e. high-speed running, meters per minute) without sufficient recovery has shown to be related to heightened risk of injury [7,8]. To adjust the load, intensity, and time duration of training sessions, the demands on soccer players in competition must be identified.

External loads of soccer players during competition are dependent upon the player's starting status. Notably, previous research in male elite [9–11] and junior league [12] soccer players reported starters covered greater total distances, and more time spent high-speed running and sprinting in competitive games compared to non-starters. Therefore, managing starters' training workload is an essential consideration following competitions, may assist in providing optimal training/recovery balance [13]. The players exposed to lower external loads during competition (i.e., non-starters) may require higher training demands immediately following competition, while still following standard periodization guidelines [14]. These discrepancies in external loads between players could consequently lead to differences in preparation and fitness level [13]. Therefore, an increased need exists for recovery for starters following games, while non-starters likely need additional conditioning to be ready for game loads.

Despite the potential consequence (i.e. risk of injury) of an imbalance in training load between starters and non-starters [10], descriptive reports on game versus practice loads by starting status is limited. While previously published studies have explored these loads in elite populations [9–11], few studies exist in regard to collegiate level athletes [15]. The structure of the collegiate soccer season is different from other elite standard leagues. The short (i.e., ~15 weeks) and congested (i.e., 2–3 matches per week) game calendar in collegiate soccer presents a degree of complexity for practitioners to consider when attempting to manage loads and maximize player health and performance. This should be further researched to provide information about how to manage players with match stimulus and to identify possible strategies to level the load with individualized training non-starters [14]. Therefore, the aim of the current study was to investigate differences in game versus practice external load between starters and non-starters during the early in-season play.

METHODS

Participants

NCAA DI male soccer athletes (n = 19) participated in this study (mean ± SD, age: 20.3 ± 0.9 yrs; body mass: 77.9 ± 6.8 kg; body height: 178.87 ± 7.18 cm; body fat: 10.0 ± 5.0%; VO_{2max}: 65.39 ± 7.61 mL/kg/min). All players were medically cleared for intercollegiate athletic participation, had the risks and benefits explained to them beforehand, signed an institutionally approved consent form to participate, and completed a medical history form. This study was conducted according to the Declaration of Helsinki guidelines and all procedures were approved by the University's Institutional Review Board for use of human subjects in research.

External Load

External load was collected during all field training sessions and games using 10 Hz GPS technology (Optimeye S5; Catapult Sports, Melbourne, Australia) (ICC=0.959, α=0.993) [17]. These devices use a minimum of 3 satellites, and units were turned on outside 30 minutes before training. Devices were worn according to manufacturer guidelines in a supportive harness positioned between the scapulae. After each practice and game, data were downloaded using the proprietary software (Catapult Sports Open Field), which automatically detects and filters data.

External load measures included: total distance covered, player load, high-speed distance (>13 mph (5.8 $m \cdot s^{-1}$)), high inertial movement analysis (IMA; >3.5 $m \cdot s^{-2}$), and repeated high intensity efforts (RHIE: <21 seconds between each effort). Player load was yielded from the triaxial accelerometer within the device as: √(∑(instantaneous rate of change in acceleration in all 3 orthogonal planes))/100.

Statistical Analysis

SPSS version 25.0 (IBM, Armonk, NY, USA) was used for all analyses. All values are presented as means ± standard deviations, and 95% Confidence

Intervals (CI).

RESULTS

The changes in training loads across time (11 sessions) were different based on player classifications (starter versus non-starter): total distance ($p<0.001$; partial eta^2: 0.416), player load ($p<0.001$; partial eta^2: 0.338), high-speed distance ($p<0.001$; partial eta^2: 0.084), IMA ($p<0.001$; partial eta2: 0.159) and RHIE ($p<0.001$; partial eta^2: 0.288). For starters, all external load measures were lower in practices compared to games (Λ =0.344, F=39.355, $p<0.001$) (Table 1). Non-starters were exposed to lower loads in practice relative to the starters' game loads (Λ =0.595, F=27.130, $p<0.001$) (Table 2). Compared to game loads, training loads for total distance, player load, high-speed distance, IMAs, and RHIEs were all significantly lower than game values ($p<0.001$).

Post hoc comparisons between starters and non-starters for total distance, player load, high-speed distance, IMA, and RHIE across the 8 training sessions and 3 games are displayed in Figures 1-5. Starters had greater external loads on game days compared to non-starters ($p<0.001$). No differences between starters and non-starters occurred in high-speed distance or IMAs for any practice session. However, starters performed higher total distance ($p=0.003$), player load ($p=0.041$), and RHIEs ($p=0.037$) during practice session three, compared to non-starters.

Table 1. Practice vs game external loads in starters

	Starting status	Practice Mean ± SD (95% CI)	Game Mean ± SD (95% CI)	% Game Load
TD (m)	S	2922 ± 1234 (2645-3197)	8064 ± 3133 (6827-9256)	36%
	NS	2694 ± 1158 (2422-2966)	1494 ± 1656 (810-2177)	33%
PL (AU)	S	369 ± 132 (340-399)	923 ± 279 (817-1029)	40%
	NS	375 ± 133 (345-407)	385 ± 175 (315-456)	40%
HSD (m)	S	63 ± 54 (46-79)	287 ± 162 (226-349)	22%
	NS	58 ± 77 (18-174)	33 ± 55 (11-56)	20%
IMA (#)	S	15 ± 9 (13-17)	34 ± 16 (28-40)	45%
	NS	13 ± 12 (10-17)	9 ± 7 (6-12)	38%
RHIE (#)	S	8 ± 5 (7-9)	23 ± 10 (19-27)	32%
	NS	6 ± 4 (5-7)	4 ± 4 (1-5)	26%

S: starters; NS: non-starters; TD: total distance; PL: player load; HSD: high-speed distance; IMA: inertial movement analysis (>3.5 m/s2); RHIE: repeated high intensity efforts

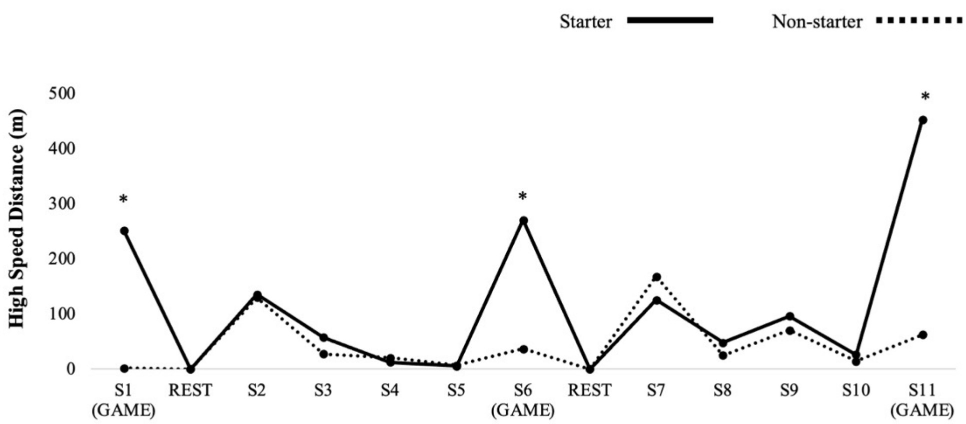

Figure 1. High-speed distance across sessions (S), including training sessions and games, in starters and non-starters; * indicates statistical significant differences across starting status with p<0.001

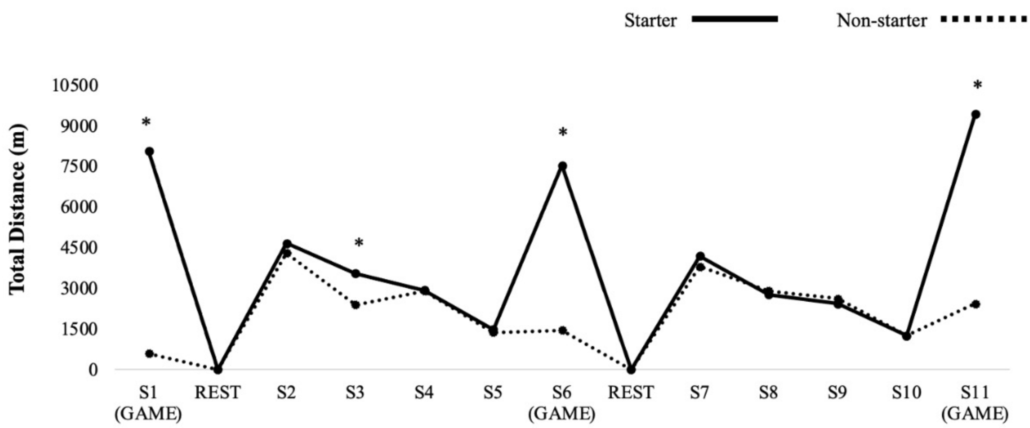

Figure 2. Total distance across sessions (S), including training sessions and games, in starters and non-starters; * indicates statistical significant differences across starting status with p<0.001

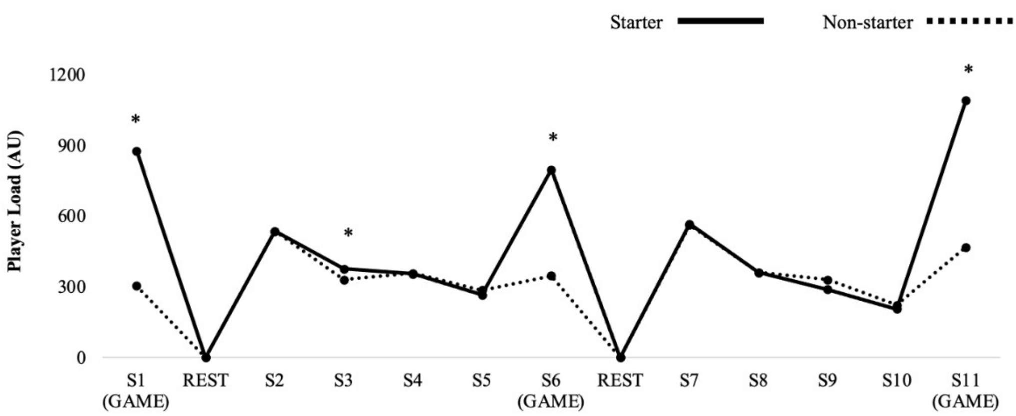

Figure 3. Player load across sessions (S), including training sessions and games, in starters and non-starters; * indicates statistical significant differences across starting status with p<0.001

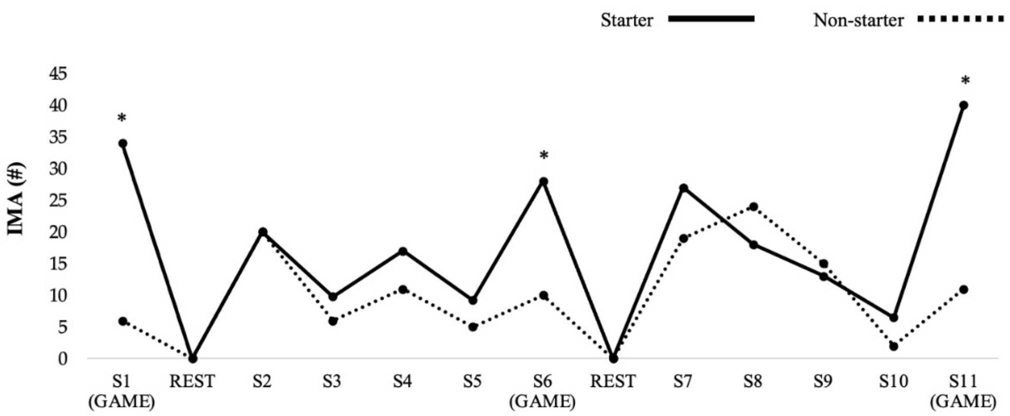

Figure 4. High inertial movement analysis (IMAs) across sessions (S), including training sessions and games, in starters and non-starters; * indicates statistical significant differences across starting status with p<0.001

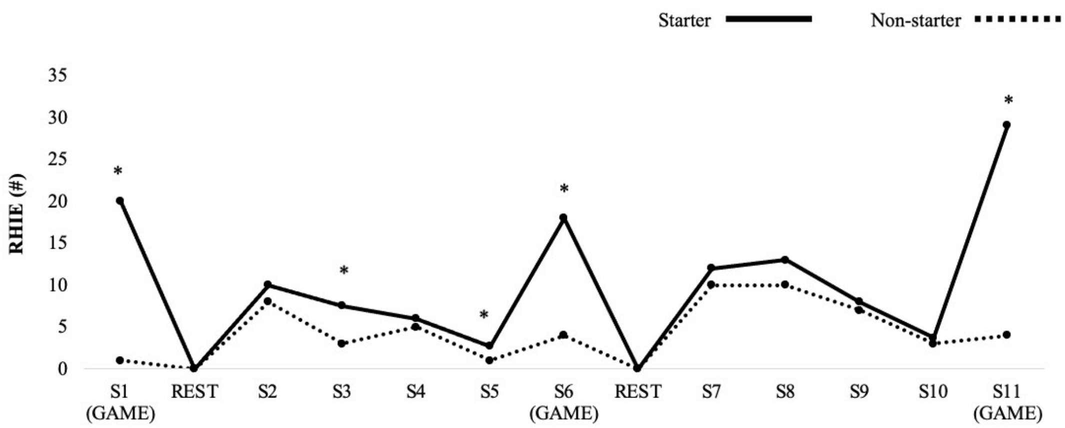

Figure 5. Repeated high intensity efforts (RHIE) across sessions (S), including training sessions and games, in starters and non-starters; * indicates statistical significant differences across starting status with p<0.001

DISCUSSION

The purpose of this study was to report differences in game versus practice external load measures between starters and non-starters during the first two weeks of in-season play in NCAA DI soccer athletes. The results provide descriptive and quantifiable information about the physical training loads experienced by NCAA DI male soccer athletes. The main finding was that starters were exposed to significantly lower external loads in practices compared to games, while non-starters were exposed to significantly lower external loads in practice relative to the starters' game loads.

Reports of external loads during the in-season period of collegiate male soccer athletes is not extensive. McFadden and colleagues explored game versus practice external loads in starters and reported a total distance of 8200 ± 1400 m (game) versus 4810 ± 400 m (practice), and sprint efforts averaged 22 ± 3 (game) versus 11 ± 3 (practice) [15]. The athletes in the current study executed similar external loads during games (total distance: 8064 ± 3133 m, RHIE: 23 ± 10 efforts), but lower external loads during practice (total distance: 2922 ± 1234 m; RHIE: 8 ± 5 efforts). Previous research in elite male soccer athletes reported that they cover total distances of ~10,000-11,000 m during games [9,11,18]. More specifically, these athletes average 879 ± 50 m of high speed distance [11], which may reach up to 2200 m in English Premier League athletes [9]. Upon comparison, starters in the current study covered less total distance (8064 ± 3133 m) and high speed distance (287 ± 162 m) than elite level athletes. Starters also had remarkedly fewer accelerations (15 ± 9 efforts) in games compared to professional players (94 ± 3 efforts) [11]. However, this large discrepancy in accelerations may be explained by the cutoff zone ranges. The current study examined exclusively high accelerations (>3.5 m/s^2), while Swallow et al. measured medium and high acceleration efforts (>2.0 m/s^2) [11]. This highlights a limitation, as arbitrary GPS thresholds were applied to monitor the external training load running performances, which can potentially be under- or over-estimated depending on their individual physical attributes [19]. In summary, the current sample presented external training loads similar to other collegiate cohorts, but less then elite players.

In practice sessions, starters (2922 ± 1234 m) and non-starters (2683 ± 1162 m) in the current study covered less total distance, on average, than professional male soccer athletes (5,223 ± 406 m) [18]. In the five days leading up to a game, total distances vary greatly from ~2600-6370 m [9,11], or 20-52% of game values [10], whereas athletes in the current study covered 1246-4659 m (20-45% of game values). Similar differences were noted for intensity metrics as well, specifically high speed distance, where values ranged from 106-539 m (12-61% of game loads) at the professional level [10,11], compared to 6-135 m (1-30% of game loads) in our collegiate population. Accelerations during training were more similar to game values (39-90%) in professional athletes, seemingly higher than the current study (starters: 45%; non-starters: 38%) [10]. While the most demanding sessions were 3-4 days prior to game, this is very difficult to achieve in the college population, where athletes play two games per week, only separated by 3-4 days. Consequently, periodization for collegiate soccer athletes is challenging, as a sufficient balance between progressive overload and recovery is essential to enhance sport performance.

An interesting finding of this study is the lack of external load that non-starters were exposed to during the beginning of the soccer season. In accordance with prior research, non-starters accumulated significantly less training load than starters, with games being the source of such differences [10,16,20]. Minimal differences in load were observed between starters and non-starters in practice sessions, highlighting the general risk for under-loading non-starters [10]. In fact, because some training sessions indicated that starters did perform higher loads than non-starters, practitioners should ensure that all athletes are exposed to similar demands. It may be beneficial for non-starters to perform separate drills that simulate physical and physiological demands of competitive matches, while starters engage in skill-based drills for adequate recovery. Consequently, a higher training intensity and/or volume during the compensatory training session carried out by the non-starters might be recommended to try to approach the game's external load experienced by the starters. Non-starters should also be encouraged to engage in supplemental running sessions on their days off or perform additional training sessions in the several days following the match. However, the precise content and magnitude of those additional training sessions for non-starters is yet to be elucidated [16].

Understanding the external loads imposed upon athletes can assist in the development of programming and periodization. Practitioners should consider a systematic approach that provides athletes a balance between overload and recovery. It may be advantageous to increase volume and intensity loads of non-starters during practices or incorporate additional conditioning sessions for positive fitness adaptations to be engendered [10,21]. If non-starting athletes remain unexposed to the heightened physical and cardiovascular loads experienced during games, they are at an increased risk of injury if subbed into the game due to drastic spikes in load [8,22,23]. Therefore, there must be a balance between high and low intensity exposures, as periods of undertraining could potentially cause players to be underprepared for the intense demands of competitive games [21,24,25]. In the current study, all external loads at practices were considered very low or low (20-45% of game loads), indicating athletes were never subjected to game loads. However, the ideal loads performed in practice sessions are unknown, especially at the collegiate level with two competitive games per week. In addition, future research should quantitatively explore loads of various drills to assist practitioners in periodization and programming of practices.

However, limitations do exist. First, this study only examined the first 11 sessions of in-season play. Fluctuations in training load may change throughout the season and may be dependent on game match-ups and outcomes. Second, no internal load measures were collected and therefore, we cannot attribute any changes in the physical work incurred during training to fatigue accumulation. Last, the results provided are from one specific collegiate DI team, and may not be generalizable to other competitive levels or teams.

While periodization remains a challenge at the collegiate level, it is recommended to keep the quality and intensity of the sessions high, but limit the duration, especially in starters, as they may need additional rest and recovery from multiple games [21]. Since collegiate soccer athletes only have 3-4 days between games, higher practice training loads may be difficult to achieve. To maintain intensity metrics while reducing the risk of injury, additional field runs can be utilized after training or as a separate activity, to ensure a sufficient amount of and high speed running and sprinting [26]. The use of medium and large-sided games can largely meet this demand, but they must be constantly monitored for each player to avoid excess intensity exposures [12,26,27]. Additionally, more effort should be taken to promote recovery, in the forms of nutrition, sleep, and other recovery modalities (i.e. ice bath, massage). Exposure to game-like volumes and intensities the day following recovery, or three prior to the competitive game [21] will ensure athletes are maintaining and improving fitness levels as preparation for game scenarios.

REFERENCES

1. Boullosa, D.; Casado, A.; Claudino, J.G.; Jiménez-Reyes, P.; Ravé, G.; Castaño-Zambudio, A.; Lima-Alves, A.; de Oliveira, S.A.; Dupont, G.; Granacher, U.; et al. Do You Play or Do You Train? Insights From Individual Sports for Training Load and Injury Risk Management in Team Sports Based on Individualization. Front Physiol 2020, 11, 995, doi:10.3389/fphys.2020.00995.
2. Taylor, K.-L.; Chapman, D.; Cronin, J.; Newton, M.; Gill, N. Fatigue Monitoring in High Performance Sport: A Survey of Current Trends. Journal of Australian Strength and Conditioning 2012, 20, 12–23.
3. Bangsbo, J.; Mohr, M.; Krustrup, P. Physical and Metabolic Demands of Training and Match-Play in the Elite Football Player. Journal of Sports Sciences 2006, 24, 665–674, doi:10.1080/02640410500482529.
4. Castillo, D.; Raya-González, J.; Clemente, F.M.; Yanci, J. The Influence of Youth Soccer Players' Sprint Performance on the Different Sided Games' External Load Using GPS Devices. Research in Sports Medicine 2020, 28, 194–205, doi:10.1080/15438627.2019.1643726.
5. Drew, M.K.; Finch, C.F. The Relationship Between Training Load and Injury, Illness and Soreness: A Systematic and Literature Review. Sports Med 2016, 46, 861–883, doi:10.1007/s40279-015-0459-8.
6. Svilar, L.; Castellano, J.; Jukic, I. Comparison of 5vs5 Training Games and Match-Play Using Microsensor Technology in Elite Basketball. The Journal of Strength & Conditioning Research 2019, 33, 1897–1903, doi:10.1519/JSC.0000000000002826.
7. Ehrmann, F.E.; Duncan, C.S.; Sindhusake, D.; Franzsen, W.N.; Greene, D.A. GPS and Injury Prevention in Professional Soccer. The Journal of Strength & Conditioning Research 2016, 30, 360–367, doi:10.1519/JSC.0000000000001093.
8. Malone, S.; Owen, A.; Mendes, B.; Hughes, B.; Collins, K.; Gabbett, T.J. High-Speed Running and Sprinting as an Injury Risk Factor in Soccer: Can Well-Developed Physical Qualities Reduce the Risk? J Sci Med Sport 2018, 21, 257–262, doi:10.1016/j.jsams.2017.05.016.
9. Kelly, D.M.; Strudwick, A.J.; Atkinson, G.; Drust, B.; Gregson, W. Quantification of Training and Match-Load Distribution across a Season in Elite English Premier League Soccer Players. Science and Medicine in Football 2020, 4, 59–67, doi:10.1080/24733938.2019.1651934.
10. Stevens, T.G.A.; Ruiter, C.J. de; Twisk, J.W.R.; Savelsbergh, G.J.P.; Beek, P.J. Quantification of In-Season Training Load Relative to Match Load in Professional Dutch Eredivisie Football Players. Science and Medicine in Football 2017, 1, 117–125, doi:10.1080/24733938.2017.1282163.
11. Swallow, W.E.; Skidmore, N.; Page, R.M.; Malone, J.J. An Examination of In-Season External Training Load in Semi-Professional Soccer Players: Considerations of One and Two Match Weekly Microcycles. International Journal of Sports Science & Coaching 2021, 16, 192–199, doi:10.1177/1747954120951762.
12. Dalen, T.; Lorås, H. Monitoring Training and Match Physical Load in Junior Soccer Players: Starters versus Substitutes. Sports 2019, 7, 70, doi:10.3390/sports7030070.
13. Nobari, H.; Oliveira, R.; Brito, J.P.; Pérez-Gómez, J.; Clemente, F.M.; Ardigò, L.P. Comparison of Running Distance Variables and Body Load in Competitions Based on Their Results: A Full-Season Study of Professional Soccer Players. Int J Environ Res Public Health 2021, 18, doi:10.3390/ijerph18042077.
14. Oliveira, R.; Palucci Vieira, L.H.; Martins, A.; Brito, J.P.; Nalha, M.; Mendes, B.; Clemente, F.M. In-Season Internal and External Workload Variations between Starters and Non-Starters—A Case Study of a Top Elite European Soccer Team. Medicina 2021, 57, 645, doi:10.3390/medicina57070645.
15. McFadden, B.A.; Walker, A.J.; Bozzini, B.N.; Sanders, D.J.; Arent, S.M. Comparison of Internal and External Training Loads in Male and Female Collegiate Soccer Players During Practices vs. Games. The Journal of Strength & Conditioning Research 2020, 34, 969–974, doi:10.1519/JSC.0000000000003485.
16. Los Arcos, A.; Mendez-Villanueva, A.; Martínez-Santos, R. In-Season Training Periodization of Professional Soccer Players. Biol Sport 2017, 34, 149–155, doi:10.5114/biolsport.2017.64588.
17. Roe, G.; Darrall-Jones, J.; Black, C.; Shaw, W.; Till, K.; Jones, B. Validity of 10-HZ GPS and Timing Gates for Assessing Maximum Velocity in Professional Rugby Union Players. Int J Sports Physiol Perform 2017, 12, 836–839, doi:10.1123/ijspp.2016-0256.
18. Anderson, L.; Orme, P.; Di Michele, R.; Close, G.L.; Morgans, R.; Drust, B.; Morton, J.P. Quantification of Training Load during One-, Two- and Three-Game Week Schedules in Professional Soccer Players from the English Premier League: Implications for Carbohydrate Periodisation. J Sports Sci 2016, 34, 1250–1259, doi:10.1080/02640414.2015.1106574.
19. Abbott, W.; Brickley, G.; Smeeton, N.J. An Individual Approach to Monitoring Locomotive Training Load in English Premier League Academy Soccer Players. International Journal of Sports Science & Coaching 2018, 13, 421–428, doi:10.1177/1747954118771181.
20. Doyle, B.; Browne, D.; Horan, D. Quantification of Internal and External Training Load during a Training Camp in Senior International Female Footballers. Science and Medicine in Football 2021, 0, 1–8, doi:10.1080/24733938.2021.1886320.
21. Favero, T.G.; White, J. Periodization in College Soccer. Strength & Conditioning Journal 2018, 40, 33–44, doi:10.1519/SSC.0000000000000385.

22. Bowen, L.; Gross, A.S.; Gimpel, M.; Bruce-Low, S.; Li, F.-X. Spikes in Acute:Chronic Workload Ratio (ACWR) Associated with a 5–7 Times Greater Injury Rate in English Premier League Football Players: A Comprehensive 3-Year Study. Br J Sports Med 2020, 54, 731–738, doi:10.1136/bjsports-2018-099422.
23. Malone, S.; Roe, M.; Doran, D.A.; Gabbett, T.J.; Collins, K.D. Protection Against Spikes in Workload With Aerobic Fitness and Playing Experience: The Role of the Acute:Chronic Workload Ratio on Injury Risk in Elite Gaelic Football. Int J Sports Physiol Perform 2017, 12, 393–401, doi:10.1123/ijspp.2016-0090.
24. Gabbett, T.J.; Ullah, S. Relationship between Running Loads and Soft-Tissue Injury in Elite Team Sport Athletes. J Strength Cond Res 2012, 26, 953–960, doi:10.1519/JSC.0b013e3182302023.
25. Hulin, B.T.; Gabbett, T.J. Indeed Association Does Not Equal Prediction: The Never-Ending Search for the Perfect Acute:Chronic Workload Ratio. Br J Sports Med 2019, 53, 144–145, doi:10.1136/bjsports-2018-099448.
26. Beato, M.; Drust, B.; Iacono, A.D. Implementing High-Speed Running and Sprinting Training in Professional Soccer. Int J Sports Med 2021, 42, 295–299, doi:10.1055/a-1302-7968.
27. Clemente, F.M.; Sarmento, H.; Rabbani, A.; Linden, C.M.I. (Niels) V.D.; Kargarfard, M.; Costa, I.T. Variations of External Load Variables between Medium- and Large-Sided Soccer Games in Professional Players. Research in Sports Medicine 2019, 27, 50–59, doi:10.1080/15438627.2018.1511560.