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External Workload Evolution and Comparison across a Pre-Season in Belgian Professional Football Players: A Pilot Study

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Abstract: The pre-season plays a crucial role in the preparation of professional football players, as it allows for an extensive focus on training sessions compared to the more congested schedules during the in-season period, especially in professional football leagues. This study aimed to describe the workload during a 6-week pre-season in Belgian professional football players and to analyse and compare the workloads for players in each microcycle according to several variables of external workload (e.g., distance covered at some velocities). Seventeen male Belgian professional football players competing in the second division of the Belgian league system participated in the study. Throughout the 6 weeks, the players were closely monitored during both training sessions and friendly matches using Global Positioning System (GPS) devices. Several parameters, including total distance covered and distance at different velocities, were recorded. Accelerating and decelerating distances, as well as the number of sprints, were also captured. Statistical analysis was based on a repeated measures ANOVA, percentage dynamics, and effect size calculations. The results obtained showed a progressive increase in the distance travelled at different intensities from week 1 (i.e., lower values) to week 3 (i.e., higher values), with reductions in these values in week 6, prior to the start of the official competition. Similarly, the peak of accelerations and decelerations were observed in week 2 and week 3, with decrements at the end of the pre-season period. This comprehensive investigation attempts to shed light on the effects and dynamic changes in external workload during the crucial pre-season, contributing valuable insights for coaches and practitioners in football conditioning and training programs, especially concerning optimal preparation for the beginning of the league's season.

Keywords: high-intensity actions; periodisation; team sports

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1. Introduction

To enhance the likelihood of success in soccer, a comprehensive approach to player preparation is essential, encompassing the technical, tactical, physical, and psychological dimensions [1]. The physical dimension of soccer has gained significant importance in recent years [2], considering soccer's nature as a highly demanding team sport [3]. The physical profile in soccer is marked by a multitude of high-intensity actions, including sprints, directional changes, jumps, and accelerations/decelerations [4]. These high-intensity actions are closely linked to soccer performance, with sprints being particularly common in goal-scoring situations [5]. Consequently, strength and conditioning coaches are keen on ensuring the optimal preparation of players to meet these demands.

To achieve this goal, various strategies have been employed, with workload monitoring [6] standing out prominently [6]. Traditionally, this approach involved the use of video data, typically obtainable only in stadiums equipped with video camera systems, to monitor the distances covered by soccer players during matches [7]. Conversely, during training sessions, only internal load metrics such as heart rate or perceived exertion could be assessed [8]. However, with the International Federation of Association Football (FIFA) now allowing the use of Global Positioning System (GPS) devices in official competitions [9], soccer clubs have integrated these devices into their facilities, enabling the monitoring of training sessions as well [10]. This strategy not only facilitates understanding the applied workload during training sessions but also enables the monitoring of sport-specific metrics of external load during matches, allowing for a comparison with training workload [11]. Additionally, GPS devices also permit the monitoring of workload throughout the entire microcycle, enabling comprehensive periodisation based on each variable and optimising training effects.

Despite this, modern soccer is characterised by chaotic and frequently changing schedules due to various factors, including television rights and progression through knock-out tournaments [12]. This results in many congested microcycles during the season, where the team plays more than one game per week, making it difficult to conduct sufficient training sessions during the in-season period [11]. Additionally, most of these training sessions are focused on post-match recovery or tapering for the subsequent match [13,14]. Thus, from a physical fitness perspective, the pre-season has gained relevance, as during this period [15,16], strength and conditioning coaches have more training time focused on physical fitness, temporarily overloading athletes' biological systems to elicit positive physiological adaptations [17]. To date, only one study has analysed the external workload imposed on professional soccer players during a pre-season [18], but these authors only considered friendly matches for this quantification. Therefore, a more comprehensive analysis of the pre-season, including training sessions and friendly matches, is required.

In this regard, this study aimed to describe the workload during a 6-week pre-season in Belgian professional soccer players and to analyse and compare the workloads of players in each microcycle according to several variables of external workload (e.g., distance covered at some velocities). Seventeen male Belgian professional soccer players competing in the second division of the Belgian league system participated in this study. We hypothesised, based on general training theory [19], that lower values in most variables are found in week 1, with progressive increases during the central part of the in-season, and stable values at the end of it, although with differences according to each external workload metric. This comprehensive approach to understanding and optimising player preparation underscores the evolution of football into a sport where scientific principles and advanced technologies play a crucial role in enhancing performance and achieving success.

2. Materials and Methods

2.1. Participants

Initially, a sample of 25 professional football players was selected. During the experimental period, three players were injured and did not complete the 6 weeks of preparation. Additionally, two young players returned to their academy team, and three left the team. Finally, 17 Belgian football players (age: 26.6 $\pm$ 4.2 years; height: 182.5 $\pm$ 06 cm; weight: 75.29 $\pm$ 7.16 kg) were included in the further analysis. These players belonged to the same team, competing in the 2nd division of the Belgium league system (the Challenger Pro League), controlled by the Royal Belgian Football Association. The team is currently in third place in the league, drawn with second position and one point away from the lead, and has been in the promotion zone from the beginning of the season. The inclusion criteria were as follows: availability during the 6 weeks of the preparatory period, absence of partial/chronic injuries (e.g., muscle–tendon or joint injuries), and a minimum of approximately 5 years of licensed football playing. The participants were informed of the procedures to be performed and provided their informed consent. The study protocol

adhered to the principles of the Declaration of Helsinki and was approved by the ethics committee of the Universidad Isabel I (code: PI-008).

2.2. Experimental Design and Procedures

A retrospective, descriptive longitudinal design was established to examine the differences in external load between each week of a pre-season period for a Belgian professional football team. The pre-season lasted 6 weeks, taking place during June, July, and August 2023. The players completed 33 training on-field sessions and 32 gym sessions. Also, the team completed 7 friendly matches under official FIFA regulations. The players wore Global Positioning System (GPS) devices to monitor their external workload during training sessions and friendly matches. Training sessions were conducted on natural grass surfaces, whilst friendly matches took place on various pitches with similar dimensions (100 m × 64 m). Prior to each training session and friendly match, the players completed a specific warm-up directed and supervised by the strength and conditioning coaches of the team. Data were gathered under favourable weather and satellite conditions for the GPS devices (with an average of 10.5 ± 0.7 satellites) during both the training sessions and friendly matches [13]. This model is based on the so-called "Microcycle Structure" model, which is characterised by a similar weekly structure for each microcycle in the pre-season and season, considering some specific training days: match day (MD + 2) was focused on compensatory and recovery effects; MD-4 was focused on developing the players' strength and power capabilities; MD-3 aimed to prepare players tactically; MD-2 was focused on technical–tactical elements; and MD-1 was a session primarily geared toward activation drills and replicating the tactical competition scenarios [13].

2.3. External Workload Quantification

The players were provided a GPS device (WIMU PRO, RealTrack Systems, Almería, Spain) to monitor their external workload during the training sessions and friendly matches that took place during the pre-season. These WIMU PRO devices include a 10-Hz GPS and 100-Hz triaxial accelerometer [20]. To reduce interunit variability, each player wore their own unit on the centre of their upper back, and each player used the same GPS device during the entire season [11]. Following the manufacturer's recommendations, all WIMU devices were activated 15 min before the start of each training session and friendly match to properly acquire satellite signals and facilitate synchronisation. The recorded data were downloaded after each register and analysed using a customised software package (WIMU SPRO, Almería, Spain). To quantify the external workload demands, the following variables were selected: total distance (TD); jogging (distance covered from 6 to 12 $km \cdot h^{-1}$); cruising (distance covered from 12 to 18 $km \cdot h^{-1}$); high-intensity running (distance covered from 18 to 21 $km \cdot h^{-1}$); high-speed running (distance covered from 21 to 24 $km \cdot h^{-1}$); and sprinting (distance covered above 24 $km \cdot h^{-1}$). Also, the number of the following variables were recorded: low-intensity accelerations (LACCs; from 3.0 to 4.0 $m \cdot s^{-2}$); high-intensity accelerations (HACCs; above 4.0 $m \cdot s^{-2}$); low-intensity decelerations (LDECs; from −4.0 to −3.0 $m \cdot s^{-2}$); and high-intensity decelerations (HDECs; below to −4.0 $m \cdot s^{-2}$). The reliability and validity of the WIMU devices for the selected variables have been previously proved [20].

2.4. Statistical Analysis

Descriptive data are presented as mean ± standard deviation (SD). The normality of the distribution and the homogeneity of variances were tested using the Shapiro–Wilk and Levene tests, respectively. A repeated measures analysis of variance (ANOVA) was performed to detect possible between-week differences in the selected external workload variables. When significant differences were obtained, a post hoc comparison (Bonferroni correction) was performed. Percentage dynamics and Cohen's *d* effect size (ES) were calculated as well. Data analysis was carried out using the Jeffrey's Amazing Statistics

Program (JASP 0.18.1; The JASP team, Amsterdam, The Netherlands), and the threshold for statistical significance was set at $p < 0.05$.

3. Results

Table 1 shows the descriptive data, in average values, related to the pre-season.

Table 1. Descriptive data (mean ± standard deviation) of the pre-season.

Variable	
Weeks (n)	6
On-field sessions (n)	33
On-field sessions (min)	5493.65 ± 296.65
Gym sessions (n)	32
Gym sessions (min)	1319.41 ± 67.03
Friendly matches (n)	7
Total distance (m)	226,921.86 ± 24,924.18
Jogging (m)	87,428.34 ± 10,895.98
Cruising (m)	39,370.52 ± 6811.27
High-intensity running (m)	8797.07 ± 1555.44
High-speed running (m)	4373.65 ± 1065.05
Sprinting (m)	1774.19 ± 651.71
LACCs (m)	1116.29 ± 208.19
HACCs (m)	234.65 ± 88.84
LDECs (m)	5132.37 ± 896.56
HDECs (m)	493.25 ± 117.97

Abbreviations: LACCs = low-intensity accelerations; HACCs: high-intensity accelerations; LDECs: low-intensity decelerations; HDECs: high-intensity decelerations.

A between-week comparison regarding the distance covered at different velocities is presented in Tables 2 and 3. The highest values of TD were observed in week 3, followed by week 2 (W2 vs. W3, $p < 0.05$; ES = 1.63, +18.58%), showing significant differences to the second cycle of the pre-season (W3 vs. W4, $p < 0.001$, ES = 4.50, −48.80%; W3 vs. W5, $p < 0.001$, ES = 5.00, −51.87%; W3 vs. W6, $p < 0.001$; ES = 3.82, −46.38%). Regarding jogging, week 1 presented significant differences compared to week 3 ($p < 0.001$, ES = 2.62, +55.10%) and week 5 ($p < 0.05$, ES = 1.24, −17.47%), while week 2 showed significant differences compared to weeks 3 ($p < 0.001$, ES = 1.64, +33.57%), 4 ($p < 0.05$, ES = 0.93, −15.65%), 5 ($p < 0.001$, ES = 1.89, −28.93%), and 6 ($p < 0.01$, ES = 0.95, −16.84%). Also, week 3 presented the highest values of distance covered at jogging ($p < 0.001$) compared to the other weeks of the pre-season. Regarding cruising, the lowest values were observed in week 5 and week 6 ($p < 0.001$), meanwhile the highest values in this category were found in week 2. In addition, significant differences ($p < 0.01$, ES = 1.09, −19.49%) were observed between week 2 and week 4.

Table 2. Values and significant differences for performance variables throughout the pre-season (first cycle).

Variable	Week 1	Week 2	Week 3
Total distance (m)	31,334.90 ± 3990.89 [a,b]	48,904.21 ± 2921.31 [b,c,d,e]	57,988.90 ± 7307.98 [c,d,e]
Jogging (m)	13,486.58 ± 1812.26 [b,d]	15,660.52 ± 2755.61 [b,c,d,e]	20,917.88 ± 3566.81 [c,d,e]
Cruising (m)	7434.68 ± 1345.96 [d,e]	7913.8 ± 1339.62 [c,d,e]	7082.24 ± 1594.67 [d,e]
High-intensity running (m)	1062.83 ± 285.87 [b]	1464.00 ± 323.17 [b]	2177.00 ± 596.92 [c,d,e]
High-speed running (m)	331.02 ± 136.37 [b,c,d,e]	560.37 ± 130.42 [b,d]	1257.05 ± 514.13 [c,d,e]
Sprinting (m)	57.90 ± 41.99 [a,b,c,d,e]	409.08 ± 117.13	326.41 ± 211.20

[a] significant differences with week 2; [b] significant differences with week 3; [c] significant differences with week 4; [d] significant differences with week 5; [e] significant differences with week 6.

Table 3. Values and significant differences for performance variables throughout the pre-season (second cycle).

Variable	Week 4	Week 5	Week 6
Total distance (m)	29,691.97 ± 5067.76	27,910.57 ± 4329.89	31,091.32 ± 6732.71
Jogging (m)	13,208.89 ± 2473.26	11,130.60 ± 1980.26	13,023.87 ± 2772.70
Cruising (m)	6370.72 ± 1480.89 [d]	4932.30 ± 1264.87	5637.50 ± 2256.06
High-intensity running (m)	1337.80 ± 319.39	1487.97 ± 721.74	1327.49 ± 550.92
High-speed running (m)	666.98 ± 210.74	843.56 ± 358.14	714.68 ± 246.95
Sprinting (m)	321.37 ± 166.99	285.61 ± 107.58	373.84 ± 227.05

[d] significant differences with week 5.

Regarding the high-intensity running and high-speed running categories, week 3 presented the highest values ($p < 0.001$). Additionally, week 1 ($p < 0.001$) and week 2 ($p < 0.05$) revealed the lowest values for distance covered while high-speed running. Finally, week 1 presented the lowest values in the distance covered while sprinting ($p < 0.001$), with there being no differences among the other weeks.

In Tables 4 and 5, the between-week differences in the acceleration and deceleration variables are shown. Regarding LACCs, the highest values were observed in week 2 and week 3 compared to the rest of the pre-season ($p < 0.001$). Regarding HACCs, the greatest values were recorded during the week 2 ($p < 0.001$), while the lowest values were observed in week 1, with significant differences compared to week 2 ($p < 0.001$, ES = 2.40, +193.52%), week 3 ($p < 0.001$, ES = 1.08, +95.01%), and week 4 ($p < 0.05$, ES = 0.93, +49.63%). In terms of decelerations, the lowest values of LDECs were observed in week 1 ($p < 0.001$). The highest values in this category were found in week 2 ($p < 0.001$), followed by week 3. Moreover, in the HDEC category, the greatest values were observed during week 4 ($p < 0.001$), with week 1 ($p < 0.001$, ES_{range} = 0.43–2.98), week 5 ($p < 0.001$, ES_{range} = 0.43–2.78), and week 6 ($p < 0.001$, ES_{range} = 0.50–2.23) being the weeks in which the distance covered while performing HDECs was the lowest, that is, at the beginning and at the end of the pre-season.

Table 4. Values and significant differences for acceleration and deceleration variables throughout the pre-season (first cycle).

Variable	Week 1	Week 2	Week 3
LACCs (n)	135.65 ± 30.64 [a,b]	281.47 ± 51.89 [c,d,e]	253.35 ± 84.88 [c,d,e]
HACCs (n)	23.59 ± 10.82 [a,b,c]	69.24 ± 24.59 [b,c,d,e]	46.00 ± 27.05 [d,e]
LDECs (n)	459.87 ± 115.56 [a,b,c,d,e]	1306.92 ± 267.87 [b,c,d,e]	1035.29 ± 290.42 [c,d,e]
HDECs (n)	42.35 ± 16.40 [a,b,c]	122.35 ± 40.32 [b,d,e]	75.82 ± 30.12 [c,d]

[a] significant differences with week 2; [b] significant differences with week 3; [c] significant differences with week 4; [d] significant differences with week 5; [e] significant differences with week 6.

Table 5. Values and significant differences for acceleration and deceleration variables throughout the pre-season (second cycle).

Variable	Week 4	Week 5	Week 6
LACCs (n)	147.88 ± 38.93	133.88 ± 28.65	164.06 ± 26.71
HACCs (n)	35.29 ± 14.08	26.88 ± 12.18	33.65 ± 10.94
LDECs (n)	808.12 ± 198.77	705.01 ± 170.40	818.69 ± 276.45
HDECs (n)	141.25 ± 44.01 [d,e]	49.24 ± 15.92	62.24 ± 23.79

[d] significant differences with week 5; [e] significant differences with week 6.

4. Discussion

The aim of this study was twofold: (1) to describe the workload during a 6-week pre-season in Belgian professional football players, and (2) to analyse and compare the workloads of players in each microcycle according to several variables of external workload

(e.g., distance covered at several velocities). The results obtained showed a progressive increase in the distance covered at different intensities from week 1 (i.e., lower values) to week 3 (i.e., higher values), with reductions in these values in week 6, prior to the start of the official competition. Similarly, the peaks of accelerations and decelerations were observed in weeks 2 and 3, with decrements at the end of the pre-season period.

Although merely descriptive, it seems appropriate to present the average values covered by the players during the pre-season, which could serve as a reference for practitioners working with football players at the professional level. In this regard, the players completed a total of 65 training sessions during the 6-week pre-season. Of these, 33 were in-field sessions (5493.65 ± 296.65 min), and 32 were gym sessions (1319.41 ± 67.03). Additionally, during the experimental period, the team played seven friendly matches. In terms of external workload, a mean of 226,921.86 ± 24,924.18 m of TD was covered, with values of 87,428.34 ± 10,895.98 m at jogging, 39,370.52 ± 6811.27 m at cruising, 8797.07 ± 1555.44 m at high-intensity running, 4373.65 ± 1065.05 m at high-speed running, and 1774.19 ± 651.71 m at sprinting. In addition, the players completed 1116.29 ± 208.19 LACC actions, 234.65 ± 88.84 HACC actions, 5132.37 ± 896.56 LDEC actions, and 493.25 ± 117.97 HDEC actions.

In general, it is highly recommended to initiate a training period after a recovery phase progressively. This is followed by overexposing the athlete to achieve various adaptations and culminating with a tapering period to ensure that the athlete reaches peak condition for competition [19]. However, in football, where numerous factors come into play, achieving this can be challenging, and each external load variables may exhibit a different loading dynamic [21]. Regarding TD, week 1 presented lower values compared to weeks 2 and 3, but the week 1 values were similar to those of weeks 4, 5, and 6. This illustrates the progressive increase in this variable until reaching values close to those observed during in-season weeks [11], similar to the distance covered at jogging. In terms of cruising distance, there was a progressive increase during the first three weeks, followed by a noticeable decrease in the values covered at this intensity in the last 3 weeks. Concerning high-intensity variables (i.e., distance covered while high-intensity running, high-speed running, and sprinting), it is important to note that during week 1, the players covered very low distances to facilitate a progressive re-adaptation to high-intensity stimuli. This approach is taken to mitigate the risk of muscle–tendon injuries [22], especially in the hamstring muscles [23]. A progressive increase is observed until week 3, where the highest values in high-intensity variables are reached. Subsequently, a stabilization in the distance covered by these high-intensity variables is observed, aiming to adapt the footballers to the load they will face during competition [19]. This periodisation strategy enables football players to attain and maintain adequate physical condition values throughout the season while reducing the risk of injuries [24].

The periodisation of acceleration and deceleration actions in football has gained significant importance in recent years [25]. These actions play a crucial role in determining performance in competition [5], especially considering recent studies that highlight the direct relationship between these actions and the risk of injury associated with the calf muscles [26]. Regarding acceleration, both variables (i.e., LACCs and HACCs) exhibited a similar pattern, with low values being found in week 1 and the highest values being found in week 2, followed by a progressive decrease with a significant increase during week 6. This pattern is likely attributable to a tapering strategy, a short period prior to competition characterised by a reduction in training volume, focusing on high-intensity actions [27]. To achieve this, implemented strategies include the application of small-sided games on a smaller pitch and short sprints with fast accelerations. The decelerations followed a similar pattern, ensuring that during the pre-season, footballers are exposed to an adequate deceleration load to enhance their performance and mitigate the risk of injury [28]. Subsequently, the load is reduced to prioritise recovery from these stimuli, followed by an increase in exposure to deceleration to achieve optimal preparation.

This study presents some limitations that must be acknowledged by practitioners. Firstly, the involvement of only one male football team makes it challenging to extrapolate the results obtained to other populations. Secondly, the consideration of only external workload implies a need for future studies that include internal workload (e.g., rate of perceived exertion or heart rate variation) to gain a comprehensive knowledge of the workloads of professional football players during the pre-season. Finally, it would be beneficial to include physical fitness tests before and after the pre-season to assess the effects of this periodisation on the physical performance of the players involved. Futures studies including a larger sample and also considering female populations are required. Moreover, incorporating internal load measures is advised to enhance our understanding of progression and periodisation in the pre-season.

5. Conclusions

This study reveals the periodisation followed by a Belgian professional football team. In this regard, the key points obtained through this analysis are a progressive increase in the distance covered at different intensities from week one (i.e., lower values) to week 3 (i.e., higher values), with reductions in these values in week 6, prior to the start of the official competition. Similarly, the peaks for accelerations and decelerations were observed in week 2 and week 3, with decrements at the end of the pre-season period. These findings could be a reference for practitioners who work with similar populations and could help in adequately periodising the pre-season to optimise the football players' performance while reducing the risk of injury. Specifically, strength and conditioning coaches in football must start the pre-season with low loads and progressively increase the loads in order for the players to achieve an adequate physical fitness level before reducing the external loads at the end of the pre-season to ensure the players are better prepared for the first match.

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