Ciencia y Fútbol
Volume 23, issue 2, pp. 1-22
Opens July 1st, closes December 31st, 2025
ISSN: 1659-4436

Pensar en Movimiento
Revista de Ciencias del Ejercicio y la Salud

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Original submission: 2024-10-14 | Resubmitted: 2025-05-16 | Accepted: 2025-05-19
Published: 2025-07-01

Doi: https://doi.org/10.15517/dd8tcs76

Associated editor in charge: Ph.D. Pedro Carazo Vargas

¿How to cite this paper?

Vasquez Bonilla, A.A., Urrutia de Freitas, S., Ugalde-Ramírez, J.A., & Carranza García, L.E. (2025). Influence of Physical Complaints on Workload and Readliness-to-Train in U23 Footballers: A preparatory Period for The Olympic Games. *Pensar en Movimiento: Revista de Ciencias del Ejercicio y la Salud,* 23(2), e9. https://doi.org/10.15517/dd8tcs76

Influence of Physical Complaints on Workload and Readiness-to-Train in U23 Footballers: A Preparatory Period for The Olympic Games

Influencia de las molestias físicas en la carga de trabajo y la preparación para el entrenamiento en futbolistas sub-23: un periodo preparatorio para los Juegos Olímpicos

Influência do desconforto físico na carga de trabalho e a preparação para o treinamento em jogadores de futebol sub-23: um período preparatório para os Jogos Olímpicos

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Abstract: This study examined the relationship between physical complaints on training load and readiness-to-train in footballers during shock microcycles and tapering periods leading up to the Olympic Games. Twenty-six under-23 footballers from the Honduras National Team participated (age: 22.5 ± 1.8 years). The external load was evaluated using global positioning system, and maximal speed (km/h), sprinting distance (>24.1 km/h), very high-intensity running distance (18.1-24 km/h), high-intensity running distance HID (15.1-18 km/h), player load, number of accelerations (+2.5 m/s²) and decelerations (-2.5 m/s²) were obtained. In addition, subjective measures such as the perceived rating exertion and the total quality of recovery scale were performed. A readiness-to-train questionnaire, encompassing mood, sleep quality, energy levels, muscle pain, nutrition, stress, and health was administered. Physical complaints were identified using the Oslo Sports Trauma Research Center questionnaire. The findings show the presence of physical complaints in both the load accumulation and the tapering periods. Footballers who experienced physical complaints showed lower perceived exertion, higher muscle soreness and poorer sleep quality, health, and motivation. Also, lower performance was demonstrated in maximal speed, sprinting, accelerations, and decelerations. Sports scientists should closely monitor physical complaints in national football teams and prevent injuries before long-duration events such as the Olympic Games.

Keywords: sports injury prevention, sports performance, team sports, football training.

Resumen: Este estudio examinó la relación entre las molestias físicas con la carga de entrenamiento y la disposición para entrenar en futbolistas, durante microciclos de choque y microciclos de descarga previos a la participación en los Juegos Olímpicos. Participaron 26 futbolistas sub-23 del equipo nacional de Honduras (edad 22.5 ± 1.8 años). La carga externa se

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evaluó mediante un sistema de posicionamiento global y se obtuvieron datos de velocidad máxima (km/h), distancia de esprint (>24.1 km/h), distancia de carrera de muy alta intensidad (18.1-24 km/h), distancia de carrera de alta intensidad (AI [15.1-18 km/h]), "player load", número de aceleraciones (+2.5 m/s²) y desaceleraciones (-2.5 m/s²). Además, se realizaron mediciones subjetivas, como la percepción del esfuerzo y la escala de calidad total de recuperación. Se administró un cuestionario para evaluar la disposición para entrenar, el cual incluía las variables de estado de ánimo, calidad del sueño, niveles de energía, dolor muscular, nutrición, estrés y salud. Los jugadores con molestias físicas fueron identificados mediante el cuestionario del Centro de Investigación de Trauma Deportivo de Oslo. Los resultados muestran la presencia de molestias físicas tanto en los períodos de acumulación de carga como en el periodo de descarga. Los futbolistas con molestias físicas mostraron una menor percepción del esfuerzo y una peor calidad del sueño, salud, dolor muscular y motivación. También, presentaron un menor rendimiento en velocidad máxima, esprint, aceleraciones y desaceleraciones. Los científicos del deporte deben monitorear las molestias físicas en equipos nacionales de fútbol y prevenir lesiones antes de eventos de larga duración como los Juegos Olímpicos.

Palabras clave: prevención de lesiones deportivas, desempeño en el deporte, deportes de equipo, entrenamiento de fútbol.

Resumo: Este estudo examinou a relação entre o desconforto físico com a carga de treinamento e a disposição para treinar em jogadores de futebol, durante microciclos de choque e microciclos de descarga antes da participação nos Jogos Olímpicos. Participaram 26 jogadores sub-23 da seleção hondurenha (22,5 ± 1,8 anos). A carga externa foi avaliada por meio de um sistema de posicionamento global e foram obtidos dados sobre velocidade máxima (km/h), distância de sprint (>24,1 km/h), distância de corrida de intensidade muito alta (18,1-24 km/h), distância de corrida de alta intensidade (AI [15,1-18 km/h]), "carga do jogador", número de acelerações (+2,5 m/s²) e desacelerações (-2,5 m/s²). Além disso, foram realizadas medidas subjetivas, como a percepção de esforço e a escala de qualidade de recuperação total. Um questionário foi aplicado para avaliar a disposição para treinar, que incluiu as variáveis humor, qualidade de sono, níveis de energia, dores musculares, nutrição, estresse e saúde. Os jogadores com desconforto físico foram identificados por meio do questionário do Centro de Pesquisa de Trauma Esportivo de Oslo. Os resultados mostram a presença de desconforto físico tanto nos períodos de acumulação de carga como no período de descarga. Os jogadores de futebol com desconforto físico apresentaram menor percepção de esforço e pior qualidade de sono, saúde, dor muscular e motivação. Eles também apresentaram desempenho inferior em velocidade máxima, sprint, acelerações e desacelerações. Os cientistas do esporte devem monitorar o desconforto físico nas seleções nacionais de futebol e prevenir lesões antes de eventos de longa duração, como os Jogos Olímpicos.

Palavras-chave: prevenção de lesões esportivas, desempenho esportivo, esportes coletivos, treinamento de futebol.

1. Introduction

Football is characterized by intermittent and high-intensity efforts, which cause substantial neuromuscular demand. In recent years, the physical demands on elite players have increased because they are exposed to a higher number of matches throughout the season (Chmura et al., 2018). Consequently, fitness coaches have shifted their focus to controlling the training load (TL) to optimize physical performance and reduce injury risk. TL is defined as the variable input that coaches use to induce a training result and is divided into external and internal loads (Impellizzeri et al., 2020). When TL planning, a structured approach with clear objectives and parameters is established to enhance performance and develop specific skills. It is important to monitor TL, but athletes often deviate from the planned load despite careful planning, resulting in less precision in training objectives. This can occur due to factors such as fatigue, previous injuries, fixtures changes, overtraining, and others factors (Impellizzeri et al., 2020).

TL monitoring, following Gabbett's model (Gabbett et al., 2017), encompasses the workload (external load), the psychophysiological response of the player (internal load), the player's tolerance to that workload (i.e., perception and fatigue), and finally, their physical and mental readiness for another training session (readiness to train/compete). In this context, readiness-to-train (RRT) can be determined through objective measures such as heart rate variability (HRV), blood and saliva indices (internal load), together with measures of speed-covered distance (Chrismas et al., 2019). While these measurements provide information about fatigue and recovery, they have limitations due to their invasive nature, limited time, and associated costs (Halson, 2014). An attractive and more practical strategy for obtaining information on footballers' response to training is using subjective measures, such as rating of perceived exertion (RPE), recovery scales, well-being questionnaires, and RTT calculations (Vasquez Bonilla et al., 2023).

Recently, the RRT questionnaire proposed by Cullen et al. (Cullen et al., 2021) was administered to footballers and proved sensitive in detecting changes in TL when combined with Global Positioning Satellite (GPS) data (Vasquez Bonilla et al., 2023). This is considered a valuable strategy for monitoring adaptation to TL. In this context, subjective monitoring of players' discomfort and physical complaints (PCs) has been associated with future injuries (Whalan et al., 2020). The injury risk is reported to be 3 to 6 times higher when previous PCs are reported within a short period (<7 days), suggesting they may be predictors of future injuries, often associated with poor TL management (Whalan et al., 2020). Typically, assessments of PCs come from The Oslo Sports Trauma Research Center (OSTRC) questionnaire, which is designed to capture complaints and illnesses (Clarsen et al., 2014). The OSTRC questionnaire aims to evaluate the consequences of overuse injuries in athletes comprises four domains based on sports participation, training volume, performance, and pain.

On the other hand, planning based on accumulation blocks followed by tapering period is common at certain moments of the season. This approach allows for a more pronounced training stimulus with a subsequent tapering effect and has been implemented in footballers (Mallo, 2011). Planning in microcycle blocks is typically feasible during the preparatory phases of international competitions such as the Olympic Games (e.g., 3 to 6 weeks), as these are considered pre-competitive and non-congested periods. Tapering can be planned in blocks with a 50% reduction in TL during the final weeks (e.g., 2 weeks) (Beltran Valls et al., 2020; Vasquez Bonilla et al., 2023). However, continuous exposure to acute load peaks can sometimes lead to decreased performance and, in worse cases, injuries and illnesses (Drew & Finch, 2016). Therefore, it is fundamental to assess of the TL during shock microcycles, as it can result in PCs among footballers, lower performance, and poor adaptation to training. Finally, there is limited knowledge about footballers' complaints during the preparatory period for the Olympic Games and how these PCs can affect TL, recovery, and RTT in elite sports teams (Haupenthal et al., 2023). It is hypothesized that PCs can negatively influence the load, RRT, and subjective recovery of footballers. This study aims to determine the influence of physical complaints on TL, recovery, and RTT during the preparatory period for the Olympic Games, focusing on shock and tapering microcycles.

2. Methods

Participants

Twenty-six footballers from the Honduras U-23 National Team participated (age 22.5 ± 1.8 years, body weight 75.9 ± 9.9 kg, height 1.79 ± 0.11 m, professional experience 4.5 ± 3.8 years). The footballers traveled to train or compete for the national team between May and July 2021. Informed consent was obtained from all participants prior to data collection and after the study protocol was reviewed by ethical approval from the University of Extremadura and approved on October 20, 2018, according to document [code: 131/18].

Procedure

A quantitative methodology with an observational and inferential design was used. 425 observation data obtained from GPS-Inertial Movement Units (IMU), and subjective measures data were collected from self-reported questionnaires during 36 training sessions. All data were obtained at the facilities of the "Sports Project: La Casa de la H," located in the city of Siguatepeque (Honduran), and covered from May 31 to July 2, 2021. To ensure consistency and accuracy, each player was assigned the same GPS device number before each session, minimizing the risk of errors associated with device variability. Subjective measures of well-being, burden, and recovery were documented through a digital questionnaire created in Google Forms. To improve the understanding of the questionnaire and the data quality, the players answered the questions one week before the training period. This allowed them to become familiar with the questionnaire and mitigate possible confusion in the following weeks of training.

Training Planning

Planning for the preparatory period spanned five weeks and was organized into five microcycles distributed across two blocks. Block 1 focused on the accumulation of load or shock and lasted three weeks, while Block 2 involved an exponential reduction of load or tapering and lasted two weeks. A weekly load verification system, categorized into three ranges (low, medium, and high), was employed to determine the planned TL for each block. Each load was specified for each microcycle based on the planning of the coach and physical trainer, as detailed in Figure 1. During the load accumulation block, the objective was to enhance physical capabilities related to high-speed intermittent exercise, including very high-intensity running and sprinting, and gym-based strength training. This block was structured over three microcycles, featuring moderate to high-load training sessions, with some days incorporating double sessions. In total, there were 24 training sessions (Figure 1). Training tasks will be designed based on Small-Side Games, Positional Games in Wide Space, Gym Strength Training, Technical-Tactical Training, Specific of the High-intensity Running, and work of repeated sprints and Friendly Matches. Emphasis was placed on training volume, with 90-minute field and 60-minute gym sessions, focusing on the number of tasks within each session. Following the three-week cumulative load block, a tapering block was implemented. During this period, players continued training at the same intensity, but the training volume was reduced by 50%. This reduction was achieved by shortening the duration of each specific training modality, effectively decreasing the total session duration. The training frequency was also reduced by 12 sessions (Figure 1). This planning system had been pre-approved by the national team's technical staff, based on previous studies (Moalla et al., 2021) and a study researchers systematic review and meta-analysis by (Vachon et al., 2021).

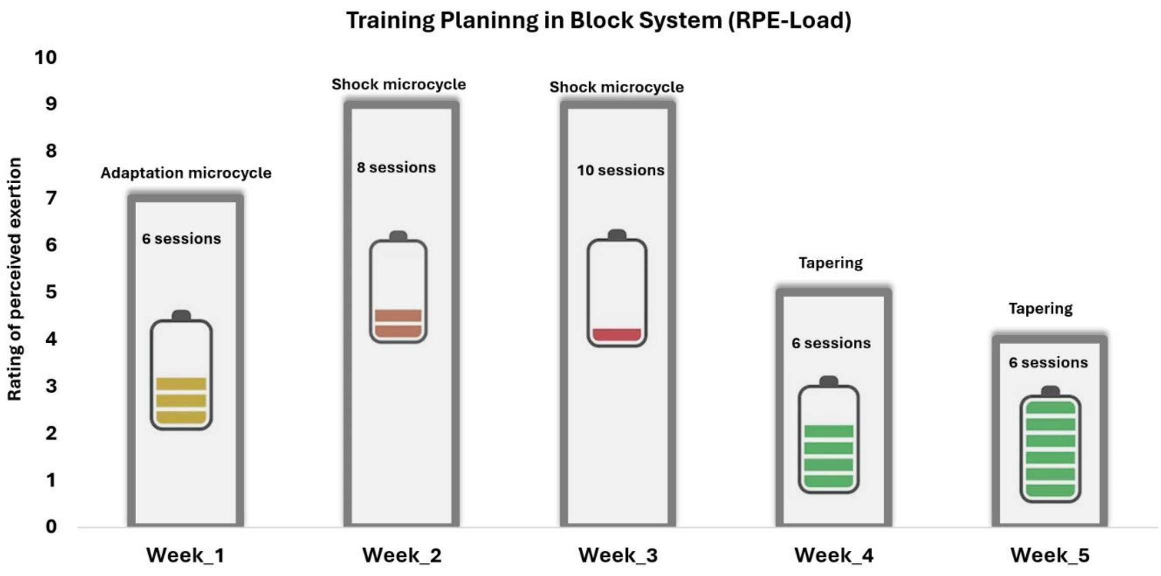

Figure 1. Estimated Energy based on Training Load planning using the player's RPE. Source: the authors.

Assessment

Global Positioning Satellite and Inertial Movement Units

Data were captured using the Optimeye S5 device (Catapult OptimEye S5, Catapult Innovations, Team Sport 5.0, Melbourne, Australia), operating at a frequency of 2.4GHz to transmit data, which was received by the GPS receiver. The Catapult Optimeye S5 units were activated 15 minutes prior to the commencement of each session and were affixed to each player's upper back using a custom-designed vest (Catapult Vest; Ventou Garment Technology, Melbourne, Australia). The scapula location, chosen for placement, has demonstrated reliability over the total distance traveled (% coefficient of variation = 1.41; minimum detectable change = 0.28) (Akyildiz et al., 2022). Additionally, the Catapult OptimEye S5 device exhibits excellent reliability with intra-class correlation coefficient (ICC) variations ranging from 0.77 (95% CI: 0.62 to 0.89) (very large) to 1.0 (95% CI: 0.99 to 1.0) (almost perfect) (Nicolella et al., 2018). After each data collection, information was downloaded from the Optimeye S5 devices onto a computer. This data was then edited and analyzed using Catapult Openfield software (Openfield®, version 1.14, Catapult Sports, Melbourne, Australia). Only subjects who completed the entire match or training session were included in the analysis. For the analysis of training load using GPS-IMU, the following variables were obtained: Total Distance covered in meters, Maximal Speed (km/h), Sprinting in meters (> 24.1 km/h), Very High-intensity distance (18.1 to 24 km/h), High-intensity distance (15.1 to 18 km/h), Very High-intensity running in meters per minute (> 18 km/h), Number of Accelerations (+ 2.5m/s²) and Decelerations (-2.5m/s²), and the sum numbers accelerations and decelerations (∑Acc+Decc), which are causes for neuromuscular fatigue (Dalen et al., 2016), and the Player Load (Load/min), which estimates the total load throughout the measure of the magnitude of acceleration of three anatomical axis during a movement using IMU (Barrett et al., 2016).

Subjective Measures of Readiness-to-train, Effort Perception, and Recovery

The RPE was assessed using Borg's CR-10 scale modified by Foster (Foster et al., 2021) and translated into Spanish. The RPE for each player's session was collected 30 minutes after each training session to ensure that perceived exertion reflected the entire session rather than just the intensity of the most recent exercise (Foster et al., 2021). Likewise, the total qualitative recovery scale (TQR) developed by Kenttä and Hassmén (Kenttä & Hassmén, 1998) served as a subjective measure to evaluate the fatigue experienced by the players. Players completed the TQR by rating their recovery on a scale of 0 to 10, with 0 indicating the worst recovery and 10 signifying extremely good recovery. This scale was completed in the morning before the training session. The TQR scale has demonstrated high reliability with a Cronbach's α value of 0.91 (Selmi et al., 2021), and it exhibited a sensitivity of 60% and specificity of 75% (Crowcroft et al., 2017). Additionally, RTT was assessed daily in the morning before the training session. The questionnaire consisted of seven dimensions rated on an ordinal scale from 1 to 5, along with sleep duration measured in hours (0 to 12 h). The descriptors were as follows: (1) Mood State (1 = very irritable, 5 = excellent mood); (2) Sleep Quality (1 = didn't sleep at all, 5 = had a great sleep); (3) Energy Levels (1 = very lethargic, 5 = full of energy); (4) Muscle soreness (1 = extremely sore, 5 = not sore at all); (5) Yesterday's Nutrition (1 = all meals high sugar/processed food, 5 = no added sugar/processed foods); (6) Stress (1 = extremely stressed, 5 = totally relaxed); (7) Health (1 = sick in bed, 5 = never better). Each descriptor contributed to the RTT value based on its weighting, with mood, energy levels, muscle readiness, stress, and health accounting for up to 15% each (i.e., 75% total). Yesterday's sleep quality and diet were up to 10% each (i.e., 20% total), while sleep duration contributed up to 5% of the overall RTT. The maximum achievable individual RTT value was 100%.

Physical complaint assessment

The term "physical complaint" refers to any discomfort that, while not causing an athlete's absence from activities, requires attention from the health team (Bahr, 2009). Consequently, during the training period, players with injuries preventing them from training with the entire team were excluded, except for those with minor injuries resulting in an absence of less than three days. They could then continue their training, as communicated by the team's physiotherapist and doctor. The criteria for injuries and training loss were based on the consensus on soccer injuries (Fuller et al., 2006). The presence and impact of physical complaints on training/match participation, performance, volume, and severity were evaluated daily using The Oslo Sports Trauma Research Center (OSTRC) Health Problems Questionnaire (Clarsen et al., 2014), translated, validated, and culturally adapted to Spanish (Bailón-Cerezo et al., 2020). Each question was streamlined to two answer options, following the methodological suggestions of Whalan et al. (2020) (see Figure 2). The OSTRC questionnaire was solely employed to register injuries and discomfort. In the adapted questionnaire's first question, players were categorized as either i) non-injured or ii) experiencing physical discomfort. Further details about each player's physical discomfort were gathered by considering discomfort's location; in the worst cases, they were referred to physiotherapists and doctors (see figure 2). A survey link was distributed via a WhatsApp group, and each player had to respond before the day's training session. The principal researcher had access to the players' data and was responsible for forwarding the questionnaire responses to the physical trainers and coaches. Additionally, the principal investigator sent a list of players who had not completed the questionnaire to the athletic trainers, prompting them to encourage players to complete the online questionnaire before the start of training.

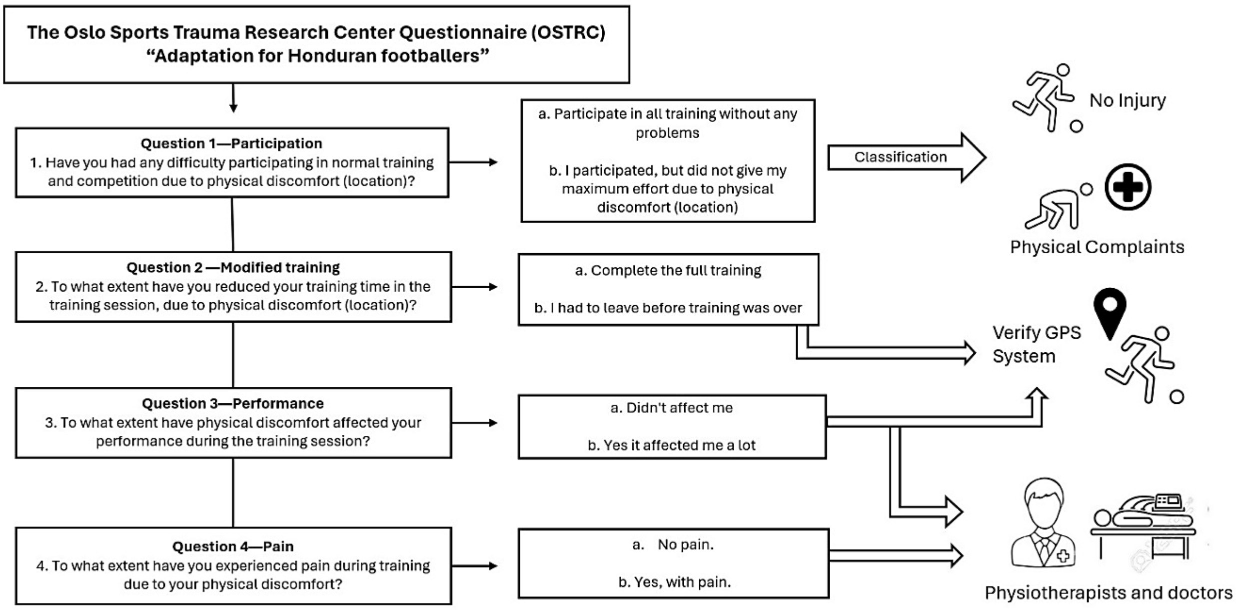

Figure 2. Protocol for action in case of physical complaints in U23 professional footballers.
Source: the authors.

Statistical Analysis

First, a descriptive exploratory analysis of the variables was carried out, expressed as mean ± SD. Subsequently, the normality of the data was assessed with the Shapiro-Wilks test, and the results for each variable ($p > 0.050$) allowed parametric tests to be applied. A Student's t-test for independent samples was performed (comparison between the absence of injuries and physical discomfort). The homogeneity was verified by the Levene test. For all analyses, a statistical significance at $p < 0.05$ was set. Also, the change percentage of each variable between the two conditions (no-injury and physical complaints) was described using the following formula: [(Variable 2 −Variable 1) / Variable 1] ×100%. Additionally, a forward stepwise binary logistic regression analysis was performed to explain the probability of predicting complaints (yes) or (no) using RTT and external GPS loading. In this way, the model eliminates variables that do not fit the model. Compliance with homoscedasticity, and non-multicollinearity were checked. The predictive power of RTT percentage on the occurrence of physical complaints was examined using receiver operating characteristic (ROC) curves. The area under the curve (AUC) was used to determine discriminatory power, with values <0.5, >0.7, and 1.0 considered poor, good, and perfect, respectively (Crowcroft et al., 2017). Sensitivity and specificity analyses of the minor and moderate complaints subcategories of the OSTRC questionnaire also determined diagnostic accuracy and predictive power (95% CI). Data was analyzed using IBM SPSS Statistics V.22.0.

3. Results

Table 1 displays the physical complaints reported by players during the preparation period for the Olympic Games and indicates the week in which each complaint was filed. Eleven players were identified, with six experiencing physical complaints during the load accumulation period and nine during the tapering period. The reported physical complaints include Psoas Discomfort, lumbar pain, Hamstring pain, Sharpshooting in the Hamstring, Calf pain, tearing sensation in the adductor, Psoas Discomfort, Hamstring pain, Psoas Discomfort, Ankle pain, and Thigh pain.

Table 1.

Physical complaints reported during block system training planning for U23 footballers.

Players	**Physical Complaints Reported**	**Physiotherapy Diagnosis**	**Presence of Physical Complaints (weeks)**				
			High Loads			**Tapering**	
			1	**2**	**3**	**4**	**5**
Player 1	Psoas Discomfort	DOMS in the left psoas (trauma)		X		X	
Player 2	lumbar pain	acromioclavicular subluxation		X	X		
Player 3	Hamstring pain	ACL reconstruction (muscle overload)	X	X	X	X	
Player 4	Sharp, shooting in Hamstring	muscle contracture			X	X	
Player 5	Calf pain	inflammation of the popliteal fossa (tendonitis)				X	X
Player 6	tearing sensation in adductor	fibrillar rupture of the left adductor (mild)					X
Player 7	Psoas Discomfort	iliopsoas tendonitis				X	X
Player 8	Hamstring pain	muscle overload				X	
Player 9	Psoas Discomfort	iliopsoas tendonitis		X		X	
Player 10	Ankle pain	left ankle sprain (grade 1)		X			
Player 11	Thigh pain	muscle overload				X	

Source: the authors.

Table 2 compares No injury and Physical Complaints (PCs) during two training periods: load accumulation and tapering. The variables examined include well-being, perception of effort, recovery scale, and RTT%. During the load accumulation block, players with physical complaints exhibited a lower RPE (Δ=20.8%), poorer sleep quality (Δ=23.1%), and health status (Δ=6.7%), and increased muscle pain (Δ=18.5%) compared to players with no injuries. Additionally, a lower RTT% (Δ=15.6%) was observed in the Physical Complaints group compared to the No-injury group. In the tapering period, players with physical complaints displayed inferior results in motivation (Δ=21.5%), sleep quality (Δ=34.4%), and RTT% (Δ=18.9%) compared to those with no injuries.

Table 3 compares the variables obtained through GPS between the No-injury and PCs groups during two training periods: load accumulation and tapering. The results indicate that, during the load accumulation period, PCs players exhibited a poorer maximum speed (Δ=13.0%), a reduced sprint distance (Δ=916.6%), and a lower number of accelerations and decelerations (Δ=76.6%) compared to No-injury players. Similarly, in the tapering period, PCs players showed inferior maximum speed (Δ=8.0%), less sprint distance (Δ=117.3%), and fewer accelerations and decelerations (Δ=155.0%). Additionally, a diminished distance of high-speed running (Δ=172.6%) and high-intensity running (Δ=113.2%) was observed in the PCs group compared to the No-injury group.

Table 4 presents the outcomes of the backward stepwise regression analysis, uncovering that sprinting <24 km/h, High-Intensity >18 km/h, and the cumulative ∑ Acceleration + Deceleration (2.5 m/s) are the variables most adept at predicting the distinction in the classification between No-injury (97%) and Physical Complaints (PCs) (67%). Likewise, the results from the backward stepwise regression analysis indicate that RPE, motivation, and muscle soreness stand out as variables that can more accurately forecast the disparity in the classification between No-injury (94%) and Physical Complaints (PCs) (64%).

Figure 3 illustrates the Receiver Operating Characteristic (ROC) curve used to assess the cut-off point for RTT% in distinguishing the player's status (No injury vs. PCs). The Area Under the Curve (AUC) is 76.24 (76%), with a Standard Error (SE) of 0.069, p-value of 0.006, and confidence limits between 62% and 89%. The Sensitivity at 0.925, and Specificity at 0.904. Therefore, we suggest using 76% RTT as a reference value to effectively discriminate PCs players from those with no injury and identify potential interference with RTT%.

Table 2.
Subjective measures of RPE, recovery, and RTT% of physical complaints vs no injury in U23 Footballers.

		Load Accumulation (3 weeks)						**Tapering (2 weeks)**					
Variable	**Conditions**	**N**	**mean**	**SD**	**F**	**Sig**	**Effect size N2p**	**N**	**mean**	**SD**	**F**	**Sig**	**Effect size N2p**
RPE	No Injury	20	7.58	2.12	6.636	**0.027***	1.013	17	5.86	2.03	0.158	0.489	0.524
	PCs	6	6.00	1.56				9	6.75	1.89			
TQR	No Injury	20	5.65	2.15	5.888	0.412	0.431	17	5.14	2.19	1.630	0.474	0.587
	PCs	6	5.40	0.58				9	4.50	1.02			
Mood State	No Injury	20	4.81	0.40	5.575	0.119	0.596	17	4.86	0.37	3.142	**0.001***	**8.600↑**
	PCs	6	4.50	0.52				9	4.00	0.10			
Sleep Quality	No Injury	20	4.31	0.44	2.724	**0.042***	**1.421↑**	17	3.86	0.90	0.807	**0.048***	1.222
	PCs	6	3.50	0.57				9	2.87	0.81			
Energy Level	No Injury	20	4.15	0.54	2.040	0.093	0.806	17	3.86	0.69	0.060	0.387	0.632
	PCs	6	3.90	0.31				9	3.50	0.57			
Muscle soreness	No Injury	20	4.15	0.73	0.528	**0.049***	0.765	17	4.14	0.57	6.283	0.481	1.114
	PCs	6	3.50	0.85				9	3.75	0.37			
Yesterday´s nutrition	No Injury	20	3.92	0.93	0.673	0.289	0.376	17	4.29	0.95	3.012	0.123	1.387
	PCs	6	3.60	0.69				9	3.50	0.57			
Strees	No Injury	20	4.19	0.63	0.081	0.162	0.322	17	4.29	0.48	14.545	0.172	0.509
	PCs	6	3.90	0.73				9	4.00	0.10			
Health	No Injury	20	4.27	0.45	115.2	**0.006***	**2.700↑**	17	4.14	0.37	4.679	0.293	0.640
	PCs	6	4.00	0.10				9	3.50	1.00			
RTT%	No Injury	20	97.90	9.06	6.832	**0.021***	**2.293↑**	17	94.17	9.32	2.477	**0.032***	**2.112↑**
	PCs	6	84.67	5.77				9	79.22	7.08			

*Statistically significant p value <0.05; interpretation of effect size = small 0.01 - Medium 0.06 - large 0.14 (↑). PCs= Physical Complaints. Source: the authors.

Table 3.
External load measurement obtained from IMU of physical complaints vs. no injury in U23 Footballers.

		Load Accumulation (3 weeks)						**Tapering** (2 weeks)					
Variable	**Conditions**	**N**	**mean**	**SD**	**F**	**Sig**	**Effect size N2p**	**N**	**mean**	**SD**	**F**	**Sig**	**Effect size N2p**
Total Distance (m)	No Injury	20	4811	2080	1.569	0.237	0.574	17	4869	1355	0.170	0.531	0.436
	PCs	6	3939	1520				9	4333	1228			
Maximal Speed (km/h)	No Injury	20	26	5	9.985	**0.043***	**1.000**↑	17	27	3	1.962	**0.016***	**1.000***
	PCs	6	23	3				9	24	2			
Sprinting (m)	No Injury	20	61	99	7.002	0.090	**3.929**↑	17	50	26	0.094	0.113	**1.227***
	PCs	6	6	14				9	23	22			
Very High-Intensity Running (m)	No Injury	20	545	494	3.847	0.218	0.346	17	409	130	0.909	**0.007***	**2.910***
	PCs	6	374	307				9	150	89			
High-intensity distance (m)	No Injury	20	1151	661	2.527	0.085	0.530	17	702	258	3.029	**0.009***	**3.182***
	PCs	6	831	438				9	317	121			
Player Load (Load/min)	No Injury	20	10	3	1	0.857	0.500	17	7	2	0.288	0.511	0.333
	PCs	6	9	2				9	6	3			
High-intensity (m/min)	No Injury	20	22	18	0.653	0.286	0.167	17	9	4	2.750	**0.007***	**2.500***
	PCs	6	19	18				9	4	2			
∑Acc+Decc (n)	No Injury	20	53	36	5.163	**0.035***	1.045	17	51	12	0.004	**0.004***	**2.214***
	PCs	6	30	22				9	20	14			
Accelerations (n)	No Injury	20	24	19	2.924	0.118	0.727	17	25	6	0.722	**0.016***	**1.500***
	PCs	6	16	11				9	10	10			
Decelerations (n)	No Injury	20	28	19	2.892	**0.045***	0.857	17	26	8	0.405	**0.002***	**3.200***
	PCs	6	16	14				9	10	5			

*Statistically significant p value <0.05; interpretation of effect size = small 0.01 - Medium 0.06 - large 0.14 (↑). PCs= Physical Complaints. Source: the authors.

Vol.23 N° 2(1-22), ISSN 1659-4436, opens July 1st, closes December 31st, 2025

Table 4.

Percentage of physical complaints prediction through subjective measures of well-being and external load obtained from IMU in U23 Footballers.

Variables	Beta	Error	Sig	Beta	Standard Error	WALD	SIG	R Square	% Probability
- Sprinting >24 Km (m) - High-Speed Running >18.1 Km/h - ∑ Acceleration + Deceleration (2.5 m/s) - Constant (K)	-0.058 0.004 -0.060 4.011	0.029 0.002 0.032 3.642	0.044 0.069 0.060 0.271	-0.932	0.327	8.093	**0.004***	0.435	No- Injury= 97% **PCs= 67%**
- RPE - Motivation - Muscle soreness - Constant (k)	-0.897 -3.345 -2.620 30.388	0.382 1.166 1.179 10.482	0.019 0.004 0.026 0.004	-0.857	0.319	7.227	**0.007***	0.579	No Injury= 94% **PCs= 64%**

*Statistically significant p value <0.05; PCs= Physical Complaints. Source: the authors.

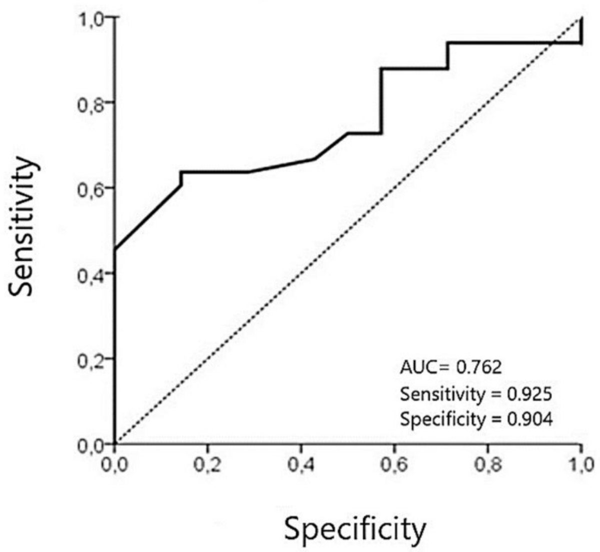

Figure 3. An analysis of the cut-off for readiness-to-train and U23 footballers with physical complaints. Source: the authors.

4. Discussion

This is the first study to determine the PCs influence on the TL and RTT in the footballers during preparatory period for the Olympic Games, using a block system planning approach based on microcycles of shock and tapering. The main finding is that players experiencing PCs showed a performance decrease, resulting in poorer RTT.

Initially, Table 1 shows that the prevalent PCs were Psoas discomfort, hamstring pain, sharp, calf pain, adductor pain, thigh pain, and ankle pain, aligning with the findings of previous studies where similar PCs were found in footballers (de Sousa Bleyer et al., 2015; Whalan et al., 2020). It is important to note that, despite the anticipated benefits of tapering, characterized by an exponential reduction in load, some players continued to experience discomfort affecting the perception of low RTT, primarily in terms of energy levels, muscle soreness, and stress. The presence of CPs could be due to the shock microcycles and insufficient pain recovery, which may persist even during the tapering period (Coutts & Reaburn, 2008). This adaptation period can lead to increased sensitivity of the nervous system, making athletes more attuned to minor discomforts or sensations potentially masked by higher training loads (Zavorsky, 2000). While some athletes may demonstrate improvement during exponential tapering, others might unexpectedly encounter discomfort due to pre-existing conditions (Edouard et al., 2023). There is a need to approach the results cautiously, considering that the perception of pain holds a biological significance in the evolution and survival of human beings. It serves a protective function by triggering unpleasant emotions. In sports, certain footballers can elevate pain thresholds (tolerance) and enhance the efficiency of processing nociceptive stimuli in the brain (Geisler et al., 2021). From this perspective, a more rigorous study could offer insights into the validity of the subjective questionnaire. An example of this could involve employing musculoskeletal ultrasound, which has demonstrated validation and reliability in identifying injury risks and developing interventions (Yim & Corrado, 2012).

Similarly, players with physical discomfort demonstrated a lower RPE (Table 2). Players with previous injuries or PCs may experience pain during usually painless movements, normally painless. This greater pain sensitivity can contribute to a reduction in exercise intensity, directly influencing the player's RPE (Marcora, 2011). Furthermore, this greater sensitivity contributes to more significant muscle pain perceived by players, altering movement patterns and instilling a feeling of not exerting maximum effort during training (Kunugi et al., 2018). Another interesting finding is that players with PCs experienced poorer sleep quality. Although the relationship between injuries and sleep quality in athletes is complex, physical discomfort emerges as a potential factor affecting sleep. Psychophysiological explanations suggest that injuries could be related to difficulties obtaining restful sleep due to discomfort or anxiety (Duffield et al., 2021).

Assessing subjective health alongside sleep quantity has been recognized as a viable strategy to mitigate injury risk, as inadequate sleep can hamper performance and lead to a low training load (Table 3) (Johnston et al., 2020). Poor sleep quality can also affect the immune system response during load acute peaks, directly influencing players' physical discomfort (Johnston et al., 2020). However, there is a need for more retrospective studies, as existing evidence is insufficient to conclusively support the theory that poor sleep independently increases the injury risk of sports or training-related accidents in athletes (Dobrosielski et al., 2021). Likewise, a motivation decrease in the players with PCs was shows during the tapering. When players undergo high training loads without adequate recovery, the positive emotional changes associated with athletic training can be reversed, pushing athletes into states of fatigue and precipitating biological and psychological disorders, including a lack of motivation (Maes et al., 2022). Ultimately, these results directly impact poorer RTT in shock and tapering periods. Furthermore, according to a conceptual review of sleep disturbances in elite players (Nédélec et al., 2015), low and high motivation to attend a major event such as the Olympic Games can trigger a stress and anxiety response that increases cognitive and physiological arousal when perceived as a threat or excessive challenge. This could lead to a state of hyperactivation, which in turn makes it difficult to get good quality sleep. Additionally, athletes may exhibit considerable interindividual variability in their sleep preferences (Nédélec et al., 2015).

Within the framework of external load used of the GPS, the findings revealed that during shock and tapering periods, players with PCs exhibited poor performance in maximal speed, sprint distances, and few accelerations and decelerations compared to their counterparts, no-injury players (Table 3). It is plausible, that players experiencing physical discomfort may consciously curtail high-intensity running and sprinting to prevent injury, aligning with findings from previous research (Timpka et al., 2020). Furthermore, pain can restrict the motion range and overall mobility, impeding the execution of explosive movements such as sprints and accelerations (Richman et al., 2019). This phenomenon manifests protective behavior, where players adopt a more cautious approach in engaging in high-impact activities. In the comprehensive context, alterations (+/-) in VHID, HID and sprint distance have been associated with an increased likelihood of injuries in elite players (Malone et al., 2018). In essence, the observed performance fluctuations show the influence of PCs on players' physical outputs and highlight the need to check tapering strategies in elite football.

Logistic regression findings revealed that running at speeds >24 km/h, >18 km/h, and the sum of acceleration + deceleration emerged as the most potent variables that discriminated RTT and player status (no-injury or PCs) (table 4). Predictive studies have indicated that injuries are more prevalent when players reach speeds greater than 25 km/h or exceed 80% of their maximum running speed, generally impacting the hamstrings (Aiello et al., 2023). As a general principle, PCs often predict performance failure, especially in sprint performance contexts (Timpka et al., 2020). Similarly, RPE, motivation, and muscle pain were the variables that best distinguished the difference in RTT among footballers. This results exploration sheds light on the holistic dynamics of the influence of PCs, performance predictors, and their interaction with footballers' RTT. Furthermore, a reference RTT cutoff point of 75% was identified to players with PCs and without injuries (Figure 3). Despite the AUC-ROC not reaching extremely high levels (above 0.8 or more), it remains greater than 0.5. This indicates that the variable RTT holds pertinent information for distinguishing between the two groups (Hand, 2010). Notably, another study has yet to evaluate RTT and its relationship to physical discomfort.

Also, using dichotomous questions in our model may yield a distinction of players with higher RTT in the training periods, which is closely associated with both pre-training and day-to-day load (Gallo et al., 2016; Lombard et al., 2021). While self-report measures have demonstrated their value in facilitating communication and dissemination of information among athletes, more research is needed to determine their objective clinical utility.

Limitations and Recommendations

This study has several methodological limitations, including the evaluation of a single group and limited data on PCs over time. However, only some studies have examined young professional footballers competing in the Olympic Games and considered an elite sample, as was done in this study. Another limitation is the absence of objective tests such as HRV and neuromuscular assessments (tensiomyography) and functional tests (CMJ) to explore associations with RTT. Despite these limitations, the knowledge gained in this study can serve as a valuable resource for employing similar approaches in injury and performance surveillance among footballers. For future research, carrying out a holistic analysis incorporating an anthropometric profile, GPS/video data analysis and worst-case scenarios during friendly matches (Aiello et al., 2023). Besides, this type of analysis must be carried out in clubs with more extended competitive periods (an entire season).

Another limitation is the lack of consensus on the data. For example, the speed zones defined by FIFA are higher than those reported in this study (Bradley, 2024). The study should be replicable in the future for national teams, and this discrepancy in the data should not be a limitation for future studies. Furthermore, regardless of the monitoring method chosen, the protocol should be individualized, cost-effective, and easy to implement to ensure the sustainability of monitoring practices.

5. Conclusions

In summary, physical complaints may be present during training periods, including shock and tapering microcycles. Football schedules are typical before long-duration competitions such as the Olympic Games. Also, PCs negatively influence performance because they can affect the training load, recovery, and RTT of under-23 footballers. Furthermore, it´s proposed that injury surveillance uses a combination of subjective reports and GPS to identify players who cannot train at an optimal level. In the future, research should continue to consider the analysis of self-report measures to foster robust research methods.

Practical applications

Sports scientists and fitness coaches must be aware of the necessity to monitor PCs, even during group training sessions. Based on the evidence from this study shows that physical complaints decrease the ability for sprinting (>24 km), high intensity running (>18.1 Km/h), and ∑ acceleration + deceleration (>2.5 m/s), which are key for the execution of explosive movements in footballers. Additionally, it is advisable to monitor RPE, motivation, and muscle soreness as warning signs to consider before and after training sessions. Future strategies should prioritize improving the RTT of each footballer and designing work methodologies tailored to each national team and sports event.

Data Availability Statement: The data supporting the findings of this study are available on the Science Data Bank website at https://www.scidb.cn/en/anonymous/N2JIYVkz.

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A-Financing,**B-**Study design, **C-**Data collection, **D-**Statistical analysis and interpretation of results, **E-**Manuscript preparation

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