



Assessing within-week changes in internal and external training demands for professional goalkeepers

Evaluación de los cambios producidos a lo largo de la semana en las demandas de entrenamiento internas y externas para porteros profesionales

Autores

José Sambade Carreira¹
 Juan José Fernández Romero¹
 José Carlos Barbero Álvarez²
 Ana Filipa Silva³
 Francisco Tomás González
 Fernández²
 Miguel Saavedra García¹

¹ Universidade da Coruña, A Coruña, Spain

² University of Granada, Granada, Spain

³ Institute, Polytechnic University of Coimbra, Coimbra, Portugal

Corresponding autor: Francisco Tomás González-Fernández, ftgonzalez@ugr.es

Received: 20-01-26

Accepted: 06-04-26

How to cite in APA

Sambade Carreira, J., Fernández Romero, J. J., Barbero Álvarez, J. C., Silva, A. F., González Fernández, F. T., & Saavedra García, M. (2026). Assessing within-week changes in internal and external training demands for professional goalkeepers. *Retos*, 80, 58-70. <https://doi.org/10.47197/retos.v80.118619>

Resumen

Introducción: En el fútbol, los porteros ocupan una posición crucial y altamente especializada que requiere características físicas y funcionales únicas, diferenciándolos claramente de los jugadores de campo.

Objetivo: Este estudio tiene como finalidad analizar y comparar de manera integral los perfiles de carga interna y externa de porteros masculinos de élite durante distintas sesiones de entrenamiento en un microciclo semanal estructurado.

Metodología: Cuatro porteros profesionales fueron reclutados mediante invitación directa. La carga interna fue medida mediante la Escala de Esfuerzo Percibido, mientras que la carga externa incluyó indicadores como la duración, la distancia total recorrida, las aceleraciones superiores a 3 m/s², las desaceleraciones inferiores a 3 m/s², la aceleración máxima y la desaceleración máxima.

Resultados: Los análisis revelaron que la carga interna, basada en la RPE, fluctuó significativamente a lo largo del microciclo ($p=0.001$, η^2 parcial=0.91), registrando picos inmediatamente después del partido y reducciones durante los días de recuperación. Las medidas de carga externa, como la distancia recorrida ($p=0.05$, η^2 parcial=0.34), las aceleraciones >3 m/s² ($p=0.001$, η^2 parcial=0.91) y las desaceleraciones <3 m/s² ($p=0.001$, η^2 parcial=0.91), también mostraron diferencias importantes, especialmente entre los días posteriores al partido y los días intermedios de la semana.

Discusión: Este estudio destaca que las cargas internas y externas en porteros de élite varían de manera significativa a lo largo del microciclo semanal, alcanzando su punto máximo en MD+3 y justo después de los partidos. Las aceleraciones >3 m/s² y las desaceleraciones >3 m/s², que superan las <3 m/s², también fluctúan a lo largo del microciclo, presentando valores pico en MD+3.

Conclusión: Monitorear ambas cargas ofrece información valiosa para ajustar estrategias de entrenamiento y recuperación de manera individualizada. Se recomienda que futuras investigaciones desarrollen sistemas en tiempo real para optimizar aún más la gestión de cargas y la prevención de lesiones.

Palabras clave

Portero, entrenamiento, carga interna, carga externa, fútbol, rendimiento.

Abstract

Introduction: In soccer, goalkeepers hold a vital and highly specialized position that demands unique physical and functional qualities, distinguishing them clearly from outfield players.

Objective: The present study aimed to comprehensively analyze and compare the internal and external workload profiles of elite male goalkeepers across various training sessions within a structured weekly microcycle.

Methodology: Four professional goalkeepers were recruited through direct invitations. Internal load was quantified using the Rating of Perceived Exertion, while external demands included measures such as duration, total distance covered, accelerations exceeding 3 m/s², decelerations below 3 m/s², maximum acceleration, and maximum deceleration.

Results: The analysis demonstrated that internal load, based on RPE, significantly fluctuated across the microcycle, $p=0.001$, η^2 partial = 0.91, with peaks immediately post-match and reductions during recovery days. External workload measures such as distance, $p=0.05$, η^2 partial = 0.34, accelerations >3 m/s², $p=0.001$, η^2 partial = 0.91, and decelerations <3 m/s², $p=0.001$, η^2 partial = 0.91, also showed significant differences, particularly between post-match and mid-weekdays.

Discussion: This study highlights that internal and external workloads in elite goalkeepers fluctuate significantly throughout the weekly microcycle, RPE reaches its highest points on MD+3 and immediately following matches. Accelerations >3 m/s², and decelerations >3 m/s²—surpassing <3 m/s², also fluctuate throughout the microcycle, with peak values observed on MD+3.

Conclusion: Monitoring both loads provides valuable insights for tailoring individualized training and recovery strategies. Future research should aim to develop real-time systems to further optimize workload management and injury prevention.

Keywords

Body composition; 10m sprint; youth soccer players; performance; VO₂ max.

Introduction

In soccer, goalkeepers occupy a crucial and highly specialized role that requires distinct functional and structural attributes, setting them apart from outfield players. Their decisions and actions often have a decisive influence on the match outcome (Nikolaidis et al., 2015). Consequently, coaching strategies emphasize key psychological and technical abilities such as concentration, decision-making, and reaction time, that underpin successful goalkeeping performance (Lethole et al., 2024). This underscores the necessity of designing tailored training programs that address the unique physical, technical, and tactical demands faced by goalkeepers during competition (Ziv & Livor, 2011). A comprehensive evaluation of goalkeeper performance should encompass multiple dimensions, including technical proficiency, physical fitness, tactical understanding, cognitive skills, mental resilience, and anthropometric characteristics among others (Szwarc et al., 2010). Understanding these diverse aspects are vital for optimizing training loads and performance outcomes, which naturally leads to an examination of how internal and external training demands evolve within a competitive microcycle.

A comprehensive, integrated methodology, as previously outlined, is fundamental for developing goalkeeper training protocols that effectively optimize performance while simultaneously reducing the likelihood of injury (Tienza-Valverde et al., 2023). This specialized training approach is particularly vital, considering that while goalkeepers typically cover approximately 4 to 6 kilometers during competitive matches, predominantly at low intensity (Pérez-Aroniz et al., 2023; White et al., 2018), their contribution to the game extends significantly beyond mere distance accumulation. Concurrently, they are also tasked with executing highly demanding, rapid decisions under pressure (Puigserver et al., 2024). Indeed, a goalkeeper's decisive impact on a match critically stems from brief, explosive actions like powerful dives, precise jumps, and agile saves. Although these occurrences are infrequent, usually ranging from 2 to 10 times per game, they are often game-changing (Lengo et al., 2019). Furthermore, unlike field players, goalkeepers must consistently maintain a vigilant, prepared stance, often in isolation, to react instantaneously to unpredictable game developments (Gryszczenko et al., 2024). This intricate interplay between low-intensity movement, sudden bursts of high-intensity effort, and continuous cognitive load truly highlights the multifaceted nature of their physical and mental requirements. A study performed by Hernández-Beltrán et al. (Hernández-Beltrán, et al., 2024) found significant differences in external load variables, such as jumps, dives, speed distances, and metabolic efforts, depending on the goalkeeper's category and sport context. These variations reflect the differing physical demands during training and matches. In the same line, another study using goalkeeping-specific micromechanical electrical systems (MEMS) revealed that training sessions often elicit a higher frequency of these explosive movements compared to match-play, emphasizing the unique physical demands faced by goalkeepers (White et al., 2020). To optimize goalkeeper performance, it is crucial for coaches to develop individualized training programs that address their specific physical and technical demands (Lethole et al., 2024; Piechota et al., 2023). Understanding the distinct challenges confronting goalkeepers is key to developing practice sessions that accurately replicate the intensity and unpredictability of competitive matches. This, in turn, significantly boosts their readiness for game situations (Malone et al., 2017; Pérez-Aroniz et al., 2023; White et al., 2018). Goalkeeper training is typically conducted independently of outfield players, allowing for a concentrated approach that prioritizes technical precision and explosive movements within restricted spaces. Such tailored instruction is vital for cultivating essential abilities like rapid reflexes and agility, thereby equipping goalkeepers to effectively react to critical, game-altering moments (Ibrahim et al., 2022; Otte et al., 2019). Ultimately, a comprehensive training strategy not only enhances physical capabilities but also fosters a resilient mentality crucial for performing under pressure, which directly translates to superior on-field execution. Furthermore, the dimensions of the training pitch considerably impact technical and tactical performance, underscoring the necessity of training environments tailored to specific contexts (Jara et al., 2018). Research indicates that training intensity is unevenly distributed across the week, with peak workloads often occurring on specific days rather than being uniform throughout (Casamichana et al., 2024). Consequently, the strategic organization of training loads within a weekly microcycle is critical for optimizing overall athletic performance in soccer (Silva et al., 2023). During match days, while demand for speed and explosive movements reaches its highest, training sessions earlier in the week are typically designed to emulate key goalkeeper actions, including diving and rapid directional changes, to enhance technical proficiency and neuromuscular readiness (White et al., 2020). The observed discrepancies in training loads between starting and substitute goalkeepers emphasize the importance of individualized training programs tailored to each



athlete's specific role and physical capacity (Vladović et al., 2023). Although global positioning system (GPS) technology provides valuable objective data on external workload, the frequent inconsistencies between these metrics and goalkeepers' subjective wellness reports highlight a significant limitation. This critical disconnect often leads to an incomplete understanding of true athlete fatigue and readiness, particularly given the unique, explosive, and intermittent demands of their position. This situation underscores the urgent need for more precise and comprehensive data collection methods that can effectively integrate and reconcile objective external load with internal physiological and psychological states to adequately address the distinct physical and psychological demands faced by goalkeepers, fostering a truly holistic approach to training load management (Grimson et al., 2023; Malone et al., 2018).

Despite significant technological progress in goalkeeper monitoring, there remains a notable lack of understanding regarding the external load factors that directly influence goalkeeper performance. This gap makes it challenging for coaches to effectively tailor training programs that meet the unique physical and technical demands of the goalkeeper position. To date, no studies have thoroughly investigated the patterns of external load or explored how internal and external workload variables interact specifically in elite goalkeepers within a structured weekly training cycle. The main aim of this research is to analyze and compare both internal and external load profiles of top-level goalkeepers across different training sessions within a standardized microcycle. By providing detailed insights into how training loads are distributed and how they relate to each other in this specialized context, our study aims to inform more targeted and individualized training strategies. Currently, the scientific literature provides limited guidance on approaches that specifically address these aspects for goalkeepers, underscoring the significance and novelty of efforts aimed at advancing goalkeeper-specific training strategies.

Method

Design

The present study adopted a longitudinal, descriptive design to investigate the training load experienced by elite male soccer goalkeepers. Data collection was conducted over the entire 2022–2023 La Liga Santander season, with careful consideration to ensure that research activities did not disrupt the teams' regular training routines, in accordance with coaching staff directives. Participants were selected through a convenience sampling approach, involving direct invitations extended to both team staff and individual goalkeepers.

Accessing professional goalkeepers for research presents significant challenges due to their highly demanding schedules and the exclusive nature of elite sport; only a small fraction of athletes achieves this professional status. Consequently, while the sample size for such specialized research might appear limited, the data gathered from these high-performing individuals offers exceptionally valuable and unique insights, providing a deep understanding of this critical position. This methodology enabled the collection of detailed, high-quality data while respecting athletes' training commitments and daily schedules. Focusing specifically on goalkeepers facilitates a nuanced understanding of the distinct physical and technical demands associated with this specialized role, providing valuable insights to inform and optimize tailored training interventions aimed at elevating performance at the highest competitive levels. Over the course of 40 weeks, data were gathered from 216 training sessions and 46 official matches, yielding a comprehensive dataset suitable for examining workload patterns and their implications across the competitive season.

Participants

This study centered on a detailed analysis of four professional goalkeepers from a single La Liga Santander team. Prior to participation, all athletes received comprehensive information regarding the study's procedures, objectives, methodologies, potential benefits, and possible risks. This ensured that each participant was fully aware of what involvement entailed, fostering informed consent and ethical transparency. The inclusion criteria required that each goalkeeper hold an active professional player license and have remained injury-free for at least two months prior to data collection, ensuring they were able to fully participate in the study. Participants also needed to have normal vision and no history of neuropsychological conditions that could affect performance or data integrity. Those who participated in at least 30 minutes of each half of official training sessions or matches were considered eligible. These



criteria were established to promote consistency and reliability in data collection, enabling a precise assessment of workload and performance patterns throughout the study period. The sample size was calculated using G*Power™ software (available at www.gpower.hhu.de), indicating that a minimum of 120 data points would be required to achieve adequate statistical power. Parameters were set at a significance level (α) of 0.05 and a power ($1 - \beta$) of 0.90, ensuring the study's capacity to detect meaningful effects. In our case, we have over 1,500 data points for each variable and a total of approximately 6,500 data points, which strongly exceeds the minimum requirement and guarantees the robustness and feasibility of the analysis. The research protocol complied with the ethical standards outlined in the Helsinki Declaration for human studies and received approval from the Research Ethics Committee of the University of Granada (approval number: 4730/CEIH/2024). This adherence underscores the commitment to ethical integrity, safeguarding participant well-being throughout the investigation.

Measures

Internal demands

To assess the internal physiological strain experienced by the goalkeepers, the CR10 Borg Perceived Exertion Scale (Foster et al., 2001) was utilized. Prior to data collection, the team was introduced to the scale, and a structured familiarization period of two weeks was incorporated into their pre-competitive training phase, during which players practiced rating their exertion daily to ensure familiarity and accuracy. Approximately 20 minutes following each training session, goalkeepers were prompted to privately rate the intensity of their workout in response to the question, "How hard was your workout today?" To enhance data integrity and confidentiality, each goalkeeper independently entered their response into questionnaire google and were processed a specified Excel spreadsheet. The researcher then collected and documented these self-reports for subsequent analysis. The recorded ratings, expressed in arbitrary units (A.U.), serve as a subjective measure of training intensity.

External demands

This study employed the WIMU PRO® GPS tracking system (Realtrack Systems, Almería, Spain) to objectively analyze the running performance of players during soccer matches. The device, weighing approximately 70 grams and measuring $81 \times 45 \times 16$ millimeters, is equipped with an array of advanced sensors, including four tri-axial accelerometers, three gyroscopes, a magnetometer, a Global Navigation Satellite System (GNSS) chip (mean positioning accuracy = 8.96 meters; standard deviation = 1.56 meters), and an Ultra-Wideband (UWB) chip (Pons et al., 2021). Data collection was performed at a sampling frequency of 10 Hz, enabling the capture of rapid movements and accelerations exceeding 3 meters per second squared (m/s^2) for durations of at least 100 milliseconds, following established protocols in sports tracking research (Malone et al., 2021). Before deployment, all devices underwent calibration and synchronization procedures in accordance with the manufacturer's guidelines to ensure data accuracy. Activation of the devices was initiated at least 20 minutes prior to each training or match session to allow sufficient satellite signal acquisition and system stabilization.

The primary performance variables analyzed included: i) Duration: Total elapsed time of the session, recorded in minutes; ii) Distance: Total distance traveled during the session, measured in meters; iii) ACC >3: Total count of accelerations exceeding $3 m/s^2$, indicating high-intensity sprinting or rapid movement; iv) DCC <3: Total count of decelerations below $-3 m/s^2$, reflecting rapid braking or slowing down; v) ACC max: The highest acceleration achieved during the session, expressed in m/s^2 ; and vi) DCC max: The most significant deceleration during the session, also in m/s^2 . The selection of these specific variables was guided by their direct availability as outputs from the GPS system and their established use within the scientific community of goalkeeper training specialists for accurately assessing and prescribing training loads. This comprehensive set of variables provides insight into the external load and movement patterns of soccer players, especially goalkeepers, during competitive play. Such detailed tracking offers valuable information for optimizing training regimens, monitoring fatigue, and preventing injury through precise workload management."

Data analysis

Descriptive statistics were computed to summarize the data, with means and standard deviations used to describe central tendency and variability. Percentages were also reported to illustrate relative proportions where applicable. Prior to any inferential analysis, the data underwent rigorous preliminary



checks to ensure the validity of the chosen statistical tests. Specifically, normality of distribution was assessed using the Kolmogorov–Smirnov test, and homogeneity of variances was examined with Levene’s test. Furthermore, for the repeated-measures analysis, the critical assumption of sphericity was evaluated using Mauchly’s test. In cases where sphericity was violated, Greenhouse–Geisser corrections were applied to adjust the degrees of freedom. This careful assessment of assumptions provides a robust foundation for the subsequent inferential findings. To examine the effects of different training days, namely Match Day (MD), MD+1, MD+2, MD–3, MD–2, and MD–1, a repeated-measures analysis of variance (ANOVA) was conducted. This approach was specifically chosen due to its suitability for analyzing within-subject variations across multiple time points, effectively controlling for individual differences and enhancing statistical power. Internal training demands were quantified using RPE, whereas external demands included variables such as: i) Duration, ii) Distance, iii) ACC>3, iv) DCC<3, v) ACC max, and vi) DCC max. The effect size for ANOVA results was expressed as partial eta squared (η^2), providing a measure of the proportion of variance explained by the effect. For planned post hoc comparisons, Cohen’s d was calculated, with interpretive thresholds set at 0.2 for small effects, 0.5 for medium, and values greater than 0.8 indicating large effects. All statistical analyses were performed using the Statistica software package (version 13.1; Statsoft, Inc., Tulsa, OK, USA), with the significance level established at $p < 0.05$.

Results

Descriptive statistics were calculated for each variable, and the results of the repeated Measures ANOVA were presented in the Table 1.

Table 1. Within-week variations (MD+1, MD+2, MD+3, MD-3, MD-2, MD-1) of Internal Demands: i) RPE, and External Demands: ii) Duration, iii) Distance; iv) ACC >3; v) DCC <3; vi) ACC max, and vii) DCC max

	MD+1 (Mean±SD)	MD+2 (Mean±SD)	MD+3 (Mean±SD)	MD-3 (Mean±SD)	MD-2 (Mean±SD)	MD-1 (Mean±SD)	Repeated Measures ANOVA
Internal Demands							
RPE (AU)	6.89± 0.56	6.54± 0.31	7.33± 0.50	5.98± 0.42	5.35± 0.49	3.84± 0.40	F =79.68 p= 0.001** $\eta^2_{\text{partial}}=.91$
External Demands							
Duration (min)	80.00± 18.20	88.65± 2.21	82.31± 5.44	80.22± 5.16	82.95± 6.55	82.01± 4.61	F =1.15 p= 0.34 $\eta^2_{\text{partial}}=.13$
Distance (m)	3455.29± 854.65	3347.55± 425.41	3310.56± 301.98	3081.37± 325.03	2959.14± 216.96	2780.77± 325.24	F =4.14 p= 0.05* $\eta^2_{\text{partial}}=.34$
ACC>3 (m/s ²)	50.23± 11.42	48.72± 11.26	70.14± 10.34	41.97± 6.72	41.48± 8.19	36.71± 5.72	F =20.82 p= 0.001** $\eta^2_{\text{partial}}=.72$
DCC<3 (m/s ²)	46.72± 11.04	48.24± 12.96	67.29± 19.61	37.11± 6.49	35.78± 6.96	31.54± 7.32	F =13.44 p= 0.001** $\eta^2_{\text{partial}}=.63$
ACC max (m/s ²)	5.56± 0.43	5.66± 0.54	5.85± 0.45	5.57± 0.25	5.42± 0.30	5.32± 0.24	F = 2.68 p= 0.07 $\eta^2_{\text{partial}}=.25$
ACC max (m/s ²)	-5.95± 0.78	-6.14± 0.23	-6.11± 0.63	-5.88± 0.15	-5.93± 0.16	-5.84± 0.34	F <1

Note: AU: Arbitrary Unity; RPE: Rate of Perceived Exertion; Duration: total duration of the season in minutes; Distance: Total distance traveled during the session, measured in meters; ACC >3: Total count of accelerations exceeding 3 m/s², indicating high-intensity sprinting or rapid movement; DCC <3: Total count of decelerations below -3 m/s², reflecting rapid braking or slowing down; ACC max: The highest acceleration achieved during the session, expressed in m/s²; and DCC max: The most significant deceleration during the session, also in m/s². * Denotes significance at $p<0.05$. and ** denotes significance

Various repeated-measures ANOVAs were conducted to examine the mean data for duration, ACCmax and DCCmax, in relation to MD conditions. The analysis did not demonstrate a statistically significant main effect for the MD condition in the case of duration, with results indicating, $F = 1.15$, $p = 0.34$, $\eta^2_{\text{partial}} = .13$. Similarly, ACCmax showed a trend toward significance, $F = 2.68$, $p = 0.07$, $\eta^2_{\text{partial}} = .25$. However, no significant differences were found for DCCmax, as the results yielded an $F < 1$, indicating



that variations in MD conditions did not significantly influence this parameter. See Figure 1, 2 and 3, for more information.

Figure 1. Within-week variations of duration (mean \pm SE)

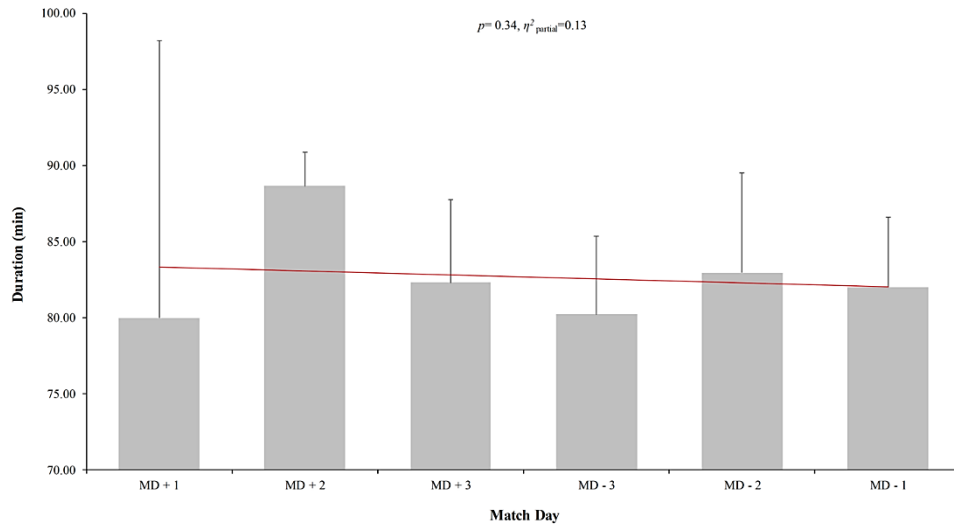


Figure 2. Within-week variations of ACC max (mean \pm SE)

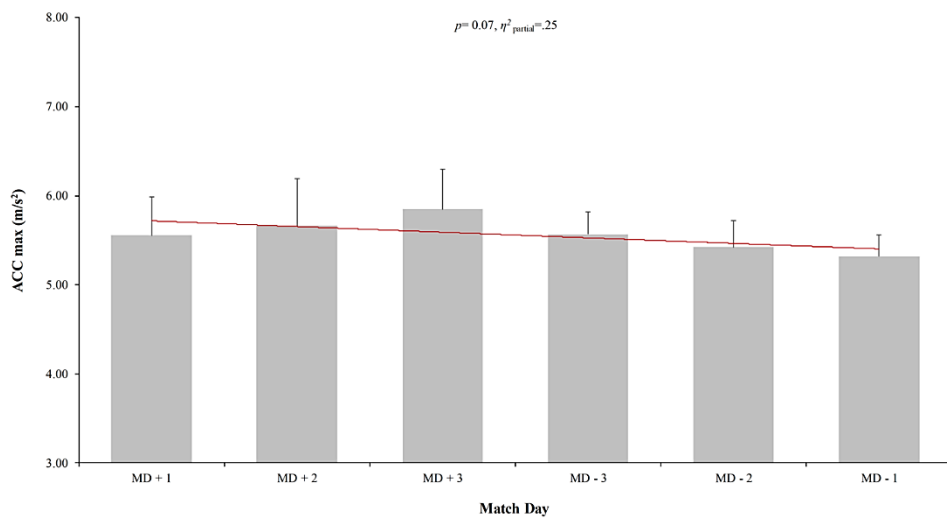
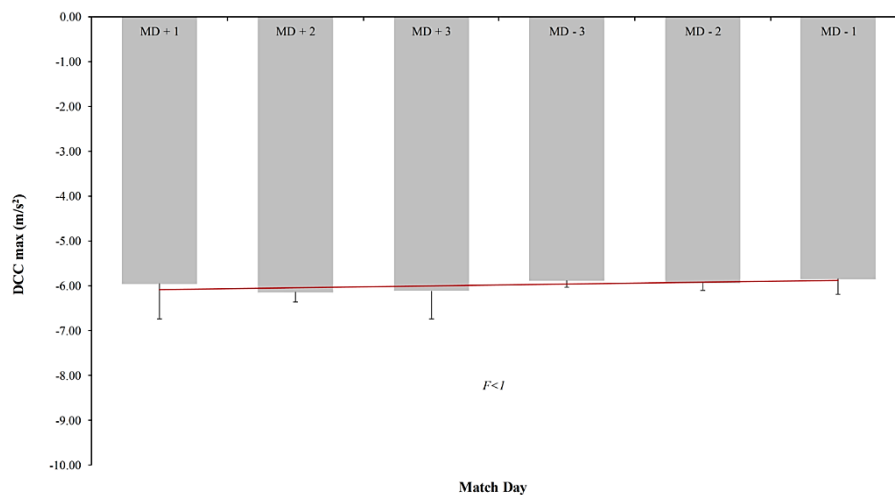
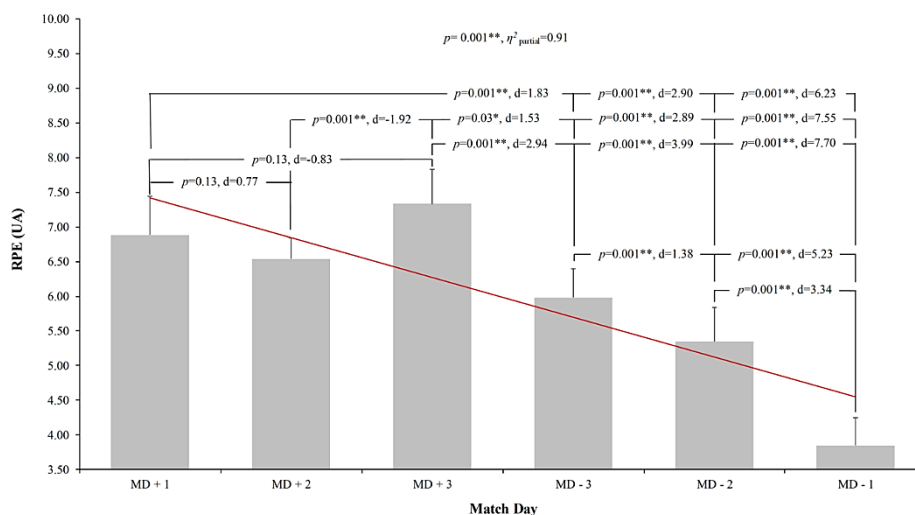


Figure 3. Within-week variations of DCC max (mean \pm SE)

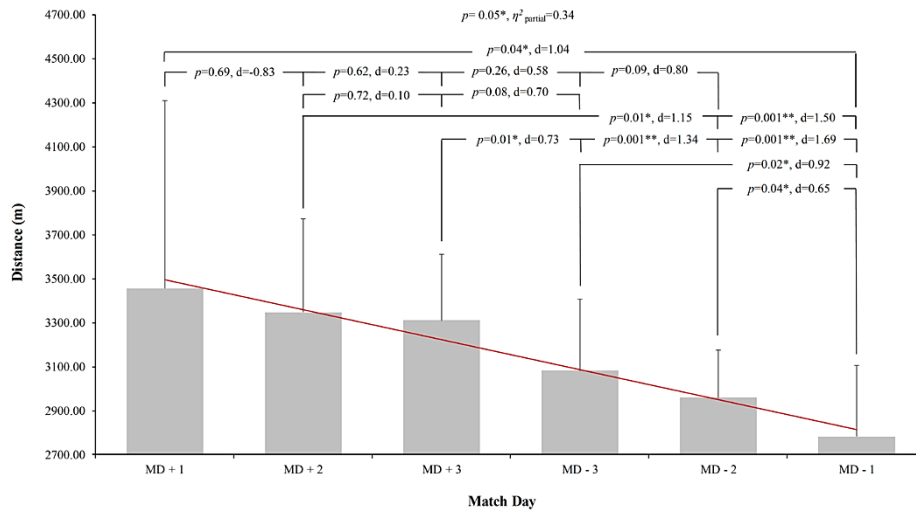
A repeated-measures ANOVA with mean data of RPE revealed a significant main effect of the MD condition: $F = 79.68$, $p = 0.001$, η^2 partial = .91. A pairwise comparison revealed significant differences between MD+1 and MD-3, $p = 0.001$, $d = 1.83$, MD+1 and MD-2, $p = 0.001$, $d = 2.90$, MD+1 and MD-1, $p = 0.001$, $d = 6.23$, MD+2 and MD+3, $p = 0.001$, $d = -1.92$, MD+2 and MD-3, $p = 0.03$, $d = 1.53$, MD+2 and MD-2, $p = 0.001$, $d = 2.89$, MD+2 and MD-1, $p = 0.001$, $d = 7.55$, MD+3 and MD-3, $p = 0.001$, $d = 2.94$, MD+3 and MD-2, $p = 0.001$, $d = 3.99$, MD+3 and MD-1, $p = 0.001$, $d = 7.70$, MD-3 and MD-2, $p = 0.001$, $d = 1.38$, MD-3 and MD-1, $p = 0.001$, $d = 5.23$, and MD-2 and MD-1, $p = 0.001$, $d = 3.34$. Crucially, the pairwise comparison did not reveal significant differences between MD+1 and MD+2, $p = 0.13$, $d = 0.77$, and MD+1 and MD+3, $p = 0.13$, $d = -0.83$ (Figure 4).

Figure 4. Within-week variations of RPE (mean \pm SE)

A new repeated-measures ANOVA with mean data of Distance revealed a significant main effect of the MD condition: $F = 4.14$, $p = 0.05^*$, η^2 partial = .34. A pairwise comparison did not show significant differences between MD+1 and MD+2, $p = 0.69$, $d = 0.16$, MD+1 and MD+3, $p = 0.62$, $d = 0.23$, MD+1 and MD-3, $p = 0.26$, $d = 0.58$, MD+1 and MD-2, $p = 0.09$, $d = 0.80$, MD+2 and MD+3, $p = 0.72$, $d = 0.10$, MD+2 and MD-3, $p = 0.08$, $d = 0.70$, MD-3 and MD-2, $p = 0.29$, $d = 0.44$. In this sense, dataset revealed some news pairwise comparison differences between, MD+1 and MD-1, $p = 0.04$, $d = 1.04$, MD+2 and MD-2, $p = 0.01$, $d = 1.15$, MD+2 and MD-1, $p = 0.001$, $d = 1.50$, MD+3 and MD-3, $p = 0.01$, $d = 0.73$, MD+3 and MD-2, $p = 0.001$, $d = 1.34$,

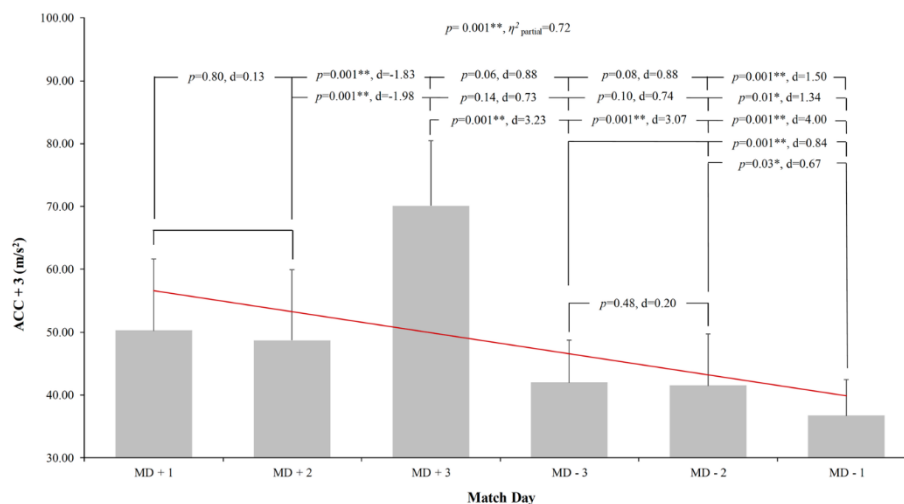
MD+3 and MD-1, $p=0.001$. $d=1.69$, MD-3 and MD-1, $p=0.02$. $d=0.92$, and MD-2 and MD-1, $p=0.04$. $d=0.65$ (Figure 5).

Figure 5. Within-week variations of Distance (mean \pm SE)



In the same line, a new repeated-measures ANOVA with mean data of ACC+3 revealed a significant main effect of the MD condition: $F = 20.82$, $p= 0.001^{**}$, η^2 partial=.72. A pairwise comparison did not show significant differences between MD+1 and MD+2, $p=0.80$. $d=0.13$, MD+1 and MD-3, $p=0.06$. $d=0.88$, MD+1 and MD-2, $p=0.08$. $d=0.88$, MD+2 and MD-3, $p=0.14$. $d=0.73$, MD+2 and MD-2, $p=0.10$. $d=0.74$, and MD-3 and MD-2, $p=0.69$. $d=0.07$. Critically, significant pairwise comparison was encountered between MD+1 and MD+3, $p=0.001$. $d=-1.83$, MD+1 and MD-1, $p=0.001$. $d=1.50$, MD+2 and MD+3, $p=0.001$. $d=-1.98$, MD+2 and MD-1, $p=0.01$, $d=1.34$, MD+3 and MD-3, $p=0.001$. $d=3.23$, MD+3 and MD-2, $p=0.001$, $d=3.07$, MD+3 and MD-1, $p=0.001$. $d=4.00$, MD-3 and MD-1, $p=0.001$. $d=0.84$, and MD-2 and MD-1, $p=0.03$. $d=0.67$. (Figure 6).

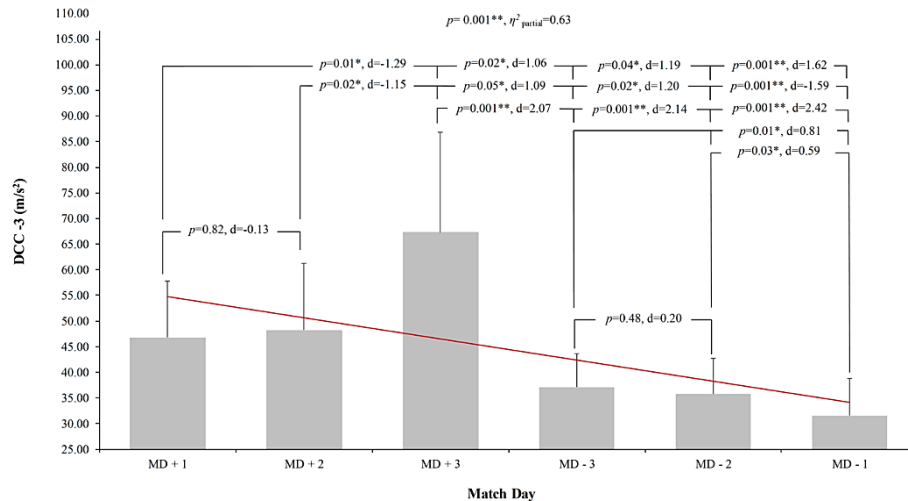
Figure 6. Within-week variations of ACC >3(mean \pm SE)



Last, a repeated-measures ANOVA with mean data of DCC-3 revealed a significant main effect of the MD condition: $F = 13.44$, $p= 0.001^{**}$, η^2 partial=.63. A pairwise comparison did not show significant diffe-

rences between MD+1 and MD+2, $p=0.82$, $d=-0.13$, and MD-3 and MD-2, $p=0.48$, $d=0.20$. Crucially, significant pairwise comparison was encountered between, MD+1 and MD+3, $p=0.01$, $d=-1.29$, MD+1 and MD-3, $p=0.02$, $d=1.06$, MD+1 and MD-2, $p=0.04$, $d=1.19$, MD+1 and MD-1, $p=0.001$, $d=1.62$, MD+2 and MD+3, $p=0.02$, $d=-1.15$, MD+2 and MD-3, $p=0.05$, $d=1.09$, MD+2 and MD-2, $p=0.02$, $d=1.20$, MD+2 and MD-1, $p=0.001$, $d=1.59$, MD+3 and MD-3, $p=0.001$, $d=2.07$, MD+3 and MD-2, $p=0.001$, $d=2.14$, MD+3 and MD-1, $p=0.001$, $d=2.42$, MD-3 and MD-1, $p=0.01$, $d=0.81$, and MD-2 and MD-1, $p=0.03$, $d=0.59$ (Figure 7).

Figure 6. Within-week variations of DCC<3 (mean \pm SE)



Discussion

The primary objective of the present study was to meticulously analyze and compare the internal and external load profiles experienced by top-level goalkeepers across different training sessions within a standardized microcycle. The findings suggest that both internal and external workloads exhibit significant fluctuations throughout the typical weekly training schedule. Specifically, the data indicate that subjective perceived exertion (RPE) tends to peak on MD+1 (immediately following matches) and on MD+3, reflecting periods of heightened internal load and acute fatigue during early recovery phases. Concurrently, external movement demands, quantified by variables such as accelerations and decelerations exceeding $>3 \text{ m/s}^2$, also demonstrate variability across training days. The highest external load values were consistently observed on MD+3, after which these loads progressively decreased, reaching their lowest levels on MD-1, the day immediately preceding the match. These insights offer valuable evidence that could inform the development of training strategies specifically tailored to the unique physical demands of goalkeepers (cf. Oliva-Lozano et al., 2020). Consequently, a thorough understanding of these load dynamics may enable coaches to design and refine training interventions that more effectively prepare goalkeepers for the physical challenges encountered during competitive matches (cf. Serrano et al., 2019).

Detailed analysis of the internal training load, as measured by RPE, revealed significant fluctuations across the microcycle, consistently observed in the studied goalkeeper cohort. As noted, peak perceived exertion was identified on MD+1 and MD+3, suggesting elevated subjective fatigue during these early and mid-recovery phases post-match. Subsequently, RPE values showed a progressive decrease, reaching their lowest levels just before the next match on MD-1. Post-hoc analyses further elucidated these patterns, demonstrating notable differences between several days. For instance, perceived exertion was substantially higher on MD+1, a finding consistent with the acute fatigue response commonly observed in the immediate post-match recovery period. Similarly, significant differences were identified when comparing MD+2 with MD+3, and between pre-match days such as MD-3 and MD-2, underscoring the close relationship between RPE and proximity to match exertion. Interestingly, no significant difference was detected between MD+1 and MD+2, which might suggest a stabilization of perceived exertion

after the initial acute recovery phase. These results align with existing research that indicates perceptions of fatigue typically peak shortly after intense exertion and gradually diminish during early recovery. This observed pattern appears to reflect common physiological and perceptual recovery processes across various athletic populations.

The utilization of RPE as an internal load indicator is broadly validated within sports science. Studies, such as that by Malone et al. (2018), have demonstrated RPE's effectiveness in tracking fatigue and exertion levels throughout competitive periods. Furthermore, considering RPE in conjunction with correlations between wellness assessments and external load metrics can provide a more comprehensive understanding of an athlete's fatigue and recovery status. Integrating RPE into load monitoring systems can thus contribute to the development of tailored training strategies aimed at maximizing performance and minimizing injury risk. Additional research, including the work by Grimson et al. (2023), has further established significant associations between externally measured workloads and perceived wellness, supporting the use of external load variables to inform personalized training prescriptions and ensure cautious interpretation of findings.

The external load analysis revealed notable fluctuations in several key metrics, including high-intensity accelerations (exceeding $>3 \text{ m/s}^2$), decelerations (below $<3 \text{ m/s}^2$), and total distance covered. These variables are often considered critical indicators of goalkeeping explosiveness, reactive agility, and overall work rate. Specifically, these high-intensity efforts appeared more frequent on certain days, particularly MD+3. This pattern could be indicative of targeted training interventions possibly designed to simulate match scenarios and enhance explosive capacity within the microcycle (cf. Otte et al., 2020). Such deliberate manipulations of training load are generally implemented with the aim of inducing beneficial physiological adaptations while effectively managing fatigue throughout the weekly cycle (cf. Hernández-Beltrán et al., 2024). As MD-1 approached, external load metrics typically decreased, exemplified by observed reductions in accelerations and decelerations between MD+3 and MD-1. This reduction is consistent with common tapering strategies, which aim to optimize athlete readiness and minimize injury risk prior to competition (cf. Casamichana et al., 2024). Furthermore, the previously noted stabilization of perceived exertion from MD+2 to MD+3 might suggest an adaptation in subjective fatigue levels, aligning with physiological recovery processes and performance optimization concepts documented in earlier research (cf. Liu et al., 2015). Conversely, the dataset did not show significant variations in session duration, ACC max, or DCC max across different days within the microcycle. This relative stability may suggest a consistent focus on maintaining technical and physical preparedness without introducing excessive fluctuations in these very high-intensity efforts. This finding aligns with previous research by Otte et al. (2020) and Casamichana et al. (2019), which emphasizes that controlled consistency in training load can be crucial for preventing overtraining and injury, thereby supporting athletes in sustaining their baseline performance over extended periods.

Monitoring and regulating both internal and external training loads are essential for optimizing goalkeeper performance. Existing research underscores that individualized load management, tailored to each athlete's specific needs and the requirements of the competition schedule, can enhance immediate performance outcomes while also promoting long-term health and resilience (Muracki et al., 2021). Strategically balancing training intensity and volume facilitates the achievement of key performance traits, such as power, agility, and endurance, while accounting for the distinct physical and tactical demands throughout the competitive cycle (Esteves et al., 2018; Tienza-Valverde et al., 2023). A comprehensive monitoring approach, integrating both subjective and objective metrics, allows for precise adjustments in training prescriptions, fostering effective recovery and enabling athletes to reach their peak capacity (Moreno-Perez, 2019). Nevertheless, certain inherent limitations of the present study merit consideration. The participant sample, composed of semi-professional athletes, constrains the generalizability of these findings to fully professional or more diverse populations. While we acknowledge that the number of goalkeepers analyzed is limited, the information obtained from each individual is extremely valuable for understanding the specific load dynamics in this unique position. This richness of individual data highlights the need to delve deeper into the analysis of the number of high-intensity actions evaluated per goalkeeper, which could offer a more granular perspective on their performance and the precise demands of their role. Furthermore, the cross-sectional design employed in this study impedes definitive causal inferences regarding the relationship between workload variables and performance or injury risk. External influences, such as psychological stress, environmental factors, and



individual differences, were not systematically controlled, which could introduce biases in the interpretation of the data. Additionally, although subjective measures like the RPE scale (rating of perceived exertion) are validated tools, their inherently perceptual nature introduces potential biases related to individual variability. These limitations underscore the critical need for combining subjective assessments with objective workload indicators to enhance the accuracy and reliability of monitoring practices. Such integrated strategies are fundamental for guiding evidence-based training interventions, optimizing recovery protocols, and ultimately supporting sustainable athlete development.

Practical Proposal

Based on these findings, a practical approach for coaching staff would be to implement personalized, periodized training schedules that carefully balance load and recovery. Training sessions should incorporate high-intensity drills, such as rapid accelerations, decelerations, and reactive movements, preferably on days with lower RPE values, to preserve key goalkeeper skills. Post-match days should feature reduced external loads to manage residual fatigue and lower injury risk. Continual, individualized monitoring of workload responses is essential to tailor interventions effectively, ensuring each goalkeeper adheres to optimal recovery timelines. Such a strategy would promote sustained high performance, reduce injury likelihood, and foster long-term athletic development tailored to the specific demands of goalkeeping.

Conclusions

This study reveals significant fluctuations in internal and external workloads in elite goalkeepers throughout the microcycle, with perceived exertion peaking on MD+3 and immediately after matches. External demands like accelerations and decelerations also peak on MD+3, then gradually decline, reaching their lowest just before matches. Monitoring these patterns is crucial for tailoring individualized training and recovery strategies that optimize performance and reduce injury risk. Future research should focus on developing real-time monitoring systems to enable dynamic workload adjustments. By integrating subjective and objective data, practitioners can craft precise training interventions, ensuring goalkeepers are adequately prepared while avoiding overtraining. This comprehensive approach supports sustainable athlete development, long-term resilience, and peak performance at the highest levels of competition.

Acknowledgements

We gratefully acknowledge the professional soccer goalkeepers and team managers for their valuable collaboration and participation in this study. Their willingness and cooperation were essential to the successful completion of the research.

Conclusions

The present study was funded by the Unit of Excellence at the University Campus of Melilla (University of Granada, Spain). Reference: UCE-PP2024-02. Additionally, it was supported by the FOOC: European Network of Football Connection: using Data Analytics to Revolutionize Talent Identification and Training in Football. Reference: 104947



References

- Borgato Gryszczenko, H., Barreira, J., Orenge Sandoval, G., & Allegretti Mercadante, L. (2024). Análisis de la eficiencia de la postura preparatoria y las acciones de anticipación realizadas por los porteros en la Copa Mundial de la FIFA 2018 (An analysis of the efficiency of preparatory posture and anticipation actions performed by goalkeepers in the 2018 FIFA World Cup). *Retos*, 57, 725-730. <https://doi.org/10.47197/retos.v57.103458>
- Casamichana, D., Barba, E., Martín-García, A., Ulloa, I., Nakamura, F., & Castellano, J. (2024). Comparison of the external load of professional goalkeepers indifferent weekly training sessions. *Biology of Sport*, 41(2), 67-72. <https://doi.org/10.5114/biolsport.2024.129484>
- Esteves, L., Santos, P., & Lago-Penas, C. (2018). Relationship between training load indicators and training periodization during preseason in elite football goalkeepers. *Human Movement Special Issues*, 89-97. <https://doi.org/10.5114/hm.2018.83217>
- Foster, C., Florhaug, J. A., Franklin, J., Gottschall, L., Hrovatin, L. A., Parker, S., Doleshal, P., & Dodge, C. (2001). A new approach to monitoring exercise training. *Journal of strength and conditioning research*, 15(1), 109-115. <https://doi.org/10.1519/00124278-200102000-00019>
- Grimson, S., Brickley, G., Smeeton, N. J., Brett, A., & Abbott, W. (2023). The Relationship Between Subjective Wellness and External Training Load in Elite English Premier League Goalkeepers and a Comparison With Outfield Soccer Players. *International Journal of Sports Physiology and Performance*, 18(3), 262-267. <https://doi.org/10.1123/ijsp.2022-0205>
- Hernández-Beltrán, V., Becerra-Patiño, B. A., Perdomo-Alonso, A., Barguerias-Martínez, J., Gómez-Carrero, S., Espada, M. C., & Gamonales, J. M. (2024). Characterization of the External Load of Soccer Goalkeepers Depending on the Category and Sports Context. *Sports*, 12(12), 318. <https://doi.org/10.3390/sports12120318>
- Ibrahim, R., de Boode, V., Kingma, I., & van Dieën, J. H. (2022). Data-driven strength and conditioning, and technical training programs for goalkeeper's diving save in football. *Sports Biomechanics*, 1-13. <https://doi.org/10.1080/14763141.2022.2099966>
- Lethole, L., Kubayi, A., Toriola, A. et al. 'Goalkeepers are players too': key attributes coaches' look for in talented youth soccer goalkeepers. *BMC Sports Sci Med Rehabil* 16, 210 (2024). <https://doi.org/10.1186/s13102-024-01002-4>
- Liu H, Gómez MA, Lago-Peñas C. Match performance profiles of goalkeepers of elite football teams. *Int J Sports Sci Coach*. 2015; 10(4):669-682.
- Longo UG, Sofi F, Dinu M, et al. Functional performance, anthropometric parameters and contribution to team success among Italian "Serie A" elite goalkeepers during season 2016-2017. *J Sports Med Phys Fitness*. 2019;59(6):969-974. <https://doi:10.23736/S0022-4707.18.08700-5>
- Malone JJ, Jaspers A, Helsen W, Merks B, Frencken WGP, Brink MS. Seasonal Training Load and Wellness Monitoring in a Professional Soccer Goalkeeper. *Int J Sports Physiol Perform*. 2018;13(5):672-675. <https://doi:10.1123/ijsp.2017-0472>
- Moreno-Pérez, V., Malone, S., Sala-Pérez, L., Lapuente-Sagarra, M., Campos-Vazquez, M. A., & Del Coso, J. (2019). Activity monitoring in professional soccer goalkeepers during training and match play. *International Journal of Performance Analysis in Sport*, 20(1), 19-30. <https://doi.org/10.1080/24748668.2019.1699386>
- Muracki, J., Klich, S., Kawczyński, A., & Boudreau, S. A. (2021). Injuries and Pain Associated with Goalkeeping in Football—Review of the Literature. *Applied Sciences*, 11(10), 4669. <https://doi.org/10.3390/app11104669>
- Nikolaidis, P., Ziv, G., Arnon, M., & Lidor, L. (2015). Physical and physiological attributes of soccer goalkeepers - Should we rely only on means and standard deviations? *J. Hum. Sport Exerc.*, 10(2), 602-614. <https://doi:10.14198/jhse.2015.102.07>
- Oliva-Lozano, J. M., Maraver, E. F., Fortes, V., & Muyor, J. M. (2020). Kinematic Analysis of the Postural Demands in Professional Soccer Match Play Using Inertial Measurement Units. *Sensors (Basel, Switzerland)*, 20(21), 5971. <https://doi.org/10.3390/s20215971>
- Otte, F., Dittmer, T., & West, J. (2023). Goalkeeping in Modern Football: Current Positional Demands and Research Insights. *International Sport Coaching Journal*, 10(1), 112-120. Retrieved Aug 5, 2025, from <https://doi.org/10.1123/iscj.2022-0012>



- Otte, F. W., Millar, S. K., & Klatt, S. (2020). How does the modern football goalkeeper train? - An exploration of expert goalkeeper coaches' skill training approaches. *Journal of sports sciences*, 38(11-12), 1465–1473. <https://doi.org/10.1080/02640414.2019.1643202>
- Perez-Arroniz, M., Calleja-González, J., Zabala-Lili, J., & Zubillaga, A. (2022). The soccer goalkeeper profile: bibliographic review. *The Physician and Sportsmedicine*, 51(3), 193–202. <https://doi.org/10.1080/00913847.2022.2040889>
- Piechota K, Majorczyk E. Decision-Making Time and Neuromuscular Coordination in Youth and Senior Soccer Goalkeepers. *Sensors*. 2023; 23(9):4483. <https://doi.org/10.3390/s23094483>
- Puigserver, P., Lavega Burgués, P., Serna, J., & Pic, M. (2024). Diseño, validación y fiabilidad de un instrumento de observación para evaluar la toma de decisión motriz en porteros de fútbol (SEDPO) (Design, validation and reliability of an observational instrument for assessing motor decision-making in football goalkeepers (SEDPO)). *Retos*, 58, 115-125. <https://doi.org/10.47197/retos.v58.105975>
- Serrano, C., Paredes-Hernández, V., Sánchez-Sánchez, J., Gallardo-Pérez, J., Da Silva, R., Porcel, D., Colino, E., García-Unanue, J., & Gallardo, L. (2019). The team's influence on physical and technical demands of elite goalkeepers in LaLiga: a longitudinal study in professional soccer. *Research in sports medicine*, 27(4), 424–438. <https://doi.org/10.1080/15438627.2018.1555755>
- Silva, H., Nakamura, F.Y., Bajanca, C., Pinto, G., Moreno-Pérez, V. & Marcelino, R. (2014). Goalkeeper horizontal accelerations and decelerations during soccer training: varying exercises could be the best option. *Journal of Physical Education and Sport*. 24 (3), 84, 711 - 719. <https://doi:10.7752/jpes.2024.03084>
- Szwarc A, Lipinska P, Chamera M. The Efficiency Model of Goalkeeper's Actions in Soccer. *Balt J Health Phys Act*. 2010;2(2):132-138. <https://doi:10.2478/v10131-0013-x>
- Tienza-Valverde, A., Hernández-Beltrán, V., Espada, M.C., Bravo-Sánchez, A., Santos, F.J. & José M. Gamonal (2023) Analysis of individual performance indicators of football goalkeeper. *Apunts Sports Medicine*, 58, 219 <https://doi.org/10.1016/j.apunsm.2023.100420>.
- Vladovic J, Versic S, Foretic N, Morgans R, Modric T. Quantification of External Training Load among Elite-Level Goalkeepers within Competitive Microcycle. *Applied Sciences*. 2023; 13(19):10880. <https://doi.org/10.3390/app131910880>
- White A, Hills SP, Cooke CB, et al. Match-Play and Performance Test Responses of Soccer Goalkeepers: A Review of Current Literature. *Sports Med*. 2018;48(11):2497-2516. <https://doi:10.1007/s40279-018-0977-2>
- White A, Hills SP, Hobbs M, et al. The physical demands of professional soccer goalkeepers throughout a week-long competitive microcycle and transiently throughout match-play. *J Sports Sci*. 2020;38(8):848-854. <https://doi:10.1080/02640414.2020.1736244>

Authors' and translators+ details

José Sambade Carreira	j.sambade@udc.es ,	Autor
Juan José Fernández Romero	juan.jose.fernandez@udc.es ,	Autor
José Carlos Barbero Álvarez	jcba@ugr.es ,	Autor
Ana Filipa Silva	anafilsilva@gmail.com ,	Autora
Francisco Tomás González Fernández	ftgonzalez@ugr.es ,	Autor
Miguel Saavedra García	miguel.saavedra@udc.es	Autor

