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The last player in football: are match preparedness and compensation an issue for goalkeepers?

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Abstract

Introduction. **During matches and training sessions, football players are exposed to different demands, which are commonly monitored to ensure that the players are prepared to cope with competition and to avoid excessive fatigue. Unfortunately, goalkeepers are often excluded from these analyses.** Aim of Study. **This study analyzed goalkeepers' demands during the days near match day (MD), including the day before (MD−1), the day after (MD+1) and a compensatory session during MD (MDC).** Material and Methods. **Three elite goalkeepers were monitored with global navigation satellite systems across a full season, leading to 291 observations. Independent mean differences compared the days for total distance, high-speed running (HSR) distance, sprint distance, maximal speeds, number of accelerations and decelerations, and player load.** Results. **During MD, players covered longer distances (total: $p < 0.001$; HSR: $p < 0.001$), reached higher maximal speeds ($p < 0.001$) and presented higher player load ($p < 0.05$) but not for total distance (higher in MD+1; $p = 0.001$), maximal speed ($p = 0.004$), and sprint distance (nonexistent in MDC). MD−1 presented similar demands ($p > 0.05$) with MD+1, except for player load (higher in MD−1; $p = 0.019$), and with MDC, except for total distance (higher in MD−1; $p < 0.001$), maximal speed (higher in MD−1; $p = 0.001$), player load (higher in MD−1; $p = 0.018$), and sprint distance (nonexistent in MDC).** Conclusions. **Our findings show that goalkeepers need a different approach regarding load distribution across the week. However, a special attention is needed regarding MDC, as this session can diminish the overall load of sprint distances covered and maximal speeds reached.**

KEYWORDS: soccer, GPS, physical demands, time-motion, locomotor patterns.

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Introduction

In football, the goalkeeper (GK) position is unique and distinct from outfield positions. This uniqueness is not only due to the possibility of manipulating the ball with the hands (when inside the penalty area) but also to the contribution regarding the match outcome, since this position function as the last line of defense, preventing the opposing team from scoring. Moreover, the GK role has been changing in response to teams' tactics and match situations, such as counterattacks that can begin with a pass from the GK [1]. On the other hand, a single mistake can lead to a goal for the opposing team, representing a singular responsibility. Besides these technical and tactical particularities, the GK also needs to cope with different physical demands such as quick reflexes, jumps, throws, stretches, dives, and sprints in multiple directions, highlighting the importance of the capacity to perform explosive movements [2]. Although GK's actions are mostly performed inside the penalty area, GKs cover around 5.6 km, with 2% of this distance being completed at high intensity [3]. However, since outfield players rarely pass the ball at distances greater than 50 m, GK need to move up the field, adopting an offensive role [4]. This can elicit from the GK the necessity to cover longer distances, which depending on the match situation (e.g., counterattacks from the opposition), can lead to intense displacements. For instance, with the GK's contact time with other players averaging 0.07 minutes per match, the interaction with other players is much lower than it is the case in other positions [5].

Considering the importance of assessing the players' load to increase match preparedness and reduce injury risk [6], researchers have extensively analyzed this topic. One monitoring strategy is to consider the microcycle (training week), where training days are classified according to the distance to the match day (MD) [7]. For example, MD−1 refers to the day before the match, and MD+1 refers to the day after the match. This strategy enables practitioners to plan their training sessions to prepare players for competition demands and to provide recovery strategies to mitigate the physical impact of matches. Furthermore, by differentiating days, it is possible to individualize the loads imposed on starters and non-starters. One study [8] reported that during the microcycle, starter GK covered greater distances compared to non-starter GK, but reported a similar number of accelerations (ACC) and decelerations (DEC). This illustrates the particularities of the GK's training, where players in this position perform more ACC and DEC during training sessions than during matches [8]. This load distribution differs from the outfield positions where matches impose higher physical demands than training sessions [9], requiring specific approaches before upcoming matches. After the match day, it is common to have conditioning training for non-starters to reduce the injury risk, increase physiological adaptations, and simulate the physical responses registered during the MD [10].

Due to the singularity of the GK position, MD+1 can present a different load than the one registered with outfield players. Specifically, GK produced similar physical responses to players in outfield positions, accumulating 400 m at speeds > 5.5 $m \cdot s^{-1}$ during MD+1. However, professional GKs were found to usually only cover around 100 m of high-speed running (HSR) on MD, even when a position-specific HSR threshold of > 4.17 $m \cdot s^{-1}$ was used [10]. Given the increased risk of injury associated with peaks in HSR load [11], caution is advised when GKs participate in post-match conditioning sessions alongside outfield players, especially as far as individuals who are not accustomed to this form of training are concerned. To assess this topic, Moreno-Pérez et al. [8] compared the load of training sessions and matches taking into account starting and non-starting GKs. They found that starting GKs covered more total distance and reported higher metabolic load efforts during the week when compared to non-starting goalkeepers. Interestingly, GKs (starters and non-starters) performed more ACC and DEC during the MD+1 session (44 ± 9 and 43 ± 11, respectively) than during MD (37 ± 13 and 36 ± 9, respectively). Of note, the MD+1 has also been classified as active recovery, where GKs reported the lowest well-being values (in response to a wellness questionnaire) during the MD–4 (four days before MD) and MD+1 sessions [12].

Besides ACC (positive and negative), it would be interesting to perceive the demands according to different variables. Specifically, considering that high-speed displacements are associated with injuries [13], assessing these variables is fundamental. Additionally, due to the particularities of the position, monitoring player load – a variable that combines ACC produced in three planes of the body movement [14], can also provide important insights into GK's load. This variable, in particular, focuses on the principal movements that GK performs during training and matches, namely actions that require changes of direction (e.g., jumps and fakes) or the ones during an abrupt initiation or cessation of a movement (e.g., collisions) [15]. Increasingly, one additional option is to provide an additional stimulus (compensation) to non-starters immediately after the match (on the same day). However, little is known regarding the demands of this strategy.

Aim of Study

The purpose of this study was to compare the external load of GKs during three specific weekdays, comprising four different activities: MD−1, MD (competition and compensation), and MD+1.

Material and Methods

Sample

From an initial sample of five professional GKs, three (n = 3) GKs participated in this study. Mean ± standard deviation (SD) age, height and body mass of the GKs were 30.7 ± 7.1, 191.3 ± 6.7, and 88.0 ± 9.5, respectively. To be included in this study, GKs needed to play a minimum of 5 matches during the season, leading to the exclusion of two GKs from the initial sample. Participants disputed the Brazilian first division and are classified as elite/international (Tier 4) [16]. An a priori power analysis was conducted using the

G-Power software (Version 3.1.9.6), which determined that 176 observations were required to achieve a power of 0.95 [17]. The number of recorded observations was 291. Since data collection was part of the team's standard procedures, written informed consent was not required, as suggested by Winter and Maughan [18] and followed by recent research [19]. Nonetheless, all data were treated anonymously in accordance with the principles of the Declaration of Helsinki, ensuring player and team confidentiality.

Procedures

Over a complete season, players were monitored during training sessions and competitive matches with a 10 Hz global navigation satellite system (WIMU Pro – Real-Track Systems). This device was certified by FIFA (Certification number: 1004497) and previously validated for collecting physical variables [20]. As instructed by the manufacturer, the devices were secured between the upper scapulae, at approximately the T3-4 junction and were activated 15 minutes before use. To mitigate interunit error, each player used the same WIMU device throughout the season. Data of the different variables were retrieved with GPS software (WIMU Spro). External load variables included total distance (m), high-speed running (HSR) distance (distance covered between 19.8–25.2 $km \cdot h^{-1}$, expressed as m), sprint distance (distance covered > 25.2 $km \cdot h^{-1}$, expressed as m), maximal speed (maximal speed achieved during each session, expressed as $km \cdot h^{-1}$), ACC (number of efforts > 3 $m \cdot s^{-2}$), DEC (i.e., negative ACC, as number of efforts < −3 $m \cdot s^{-2}$), and player load (combines ACC produced in three planes of body movement [14], and expressed with arbitrary units [a.u.]). Data were collected for three days: MD−1 (n = 170 observations), MD, and MD+1 (n = 43 observations). Additionally, the MD was divided in two different sessions: the actual competition match (MD; n = 53 observations), and the compensatory session (MDC; n = 25 observations), completed by GKs who did not participate in the match. During the matches, only data from the competition were retrieved, excluding warm-ups. Warm-ups were included in training sessions. MD−1 included low-volume drills focusing on reaction speed, crossings, and passing. MD+1 primarily featured moderate-volume drills emphasizing coordination, agility, and positional play. MDC incorporated low-volume activities, including recreational games and finishing drills.

Statistical analysis

The mean ± SD was calculated for each variable, according to the different days (MD−1, MD, MDC, MD+1). Independent mean differences (with 95% confidence intervals [CI]) with Cohen's (*d*) effect sizes [95% CI] were performed to assess the differences between the days. Cohen's (d) effect sizes were established as trivial (<0.2), small (0.2 < 0.6), moderate (0.6 < 1.2), large (1.2 < 2.0), very large (2.0 < 4.0) and extremely large (> 4.0) [21]. If the CI crossed zero, the effect size was considered unclear (p > 0.05) [22]. All statistical analyses were performed using Microsoft Excel (Microsoft Corporation; Version 16.68) and Jamovi (with ESCI package) (Jamovi, 2022; R Core Team, 2021).

Results

The means ± SD of the different variables (total distance, HSR distance, sprint distance, maximal speed, ACC, DEC, and player load) for each day are presented in Table 1.

Independent mean differences are presented in Table 2 and the effect sizes (d [95% CI]) of the differences are represented in Figure 1. Since no sprint distances were registered during MDC, no comparisons were available for this variable with this day.

Table 1. Mean ± SD of the training load variables according to each day

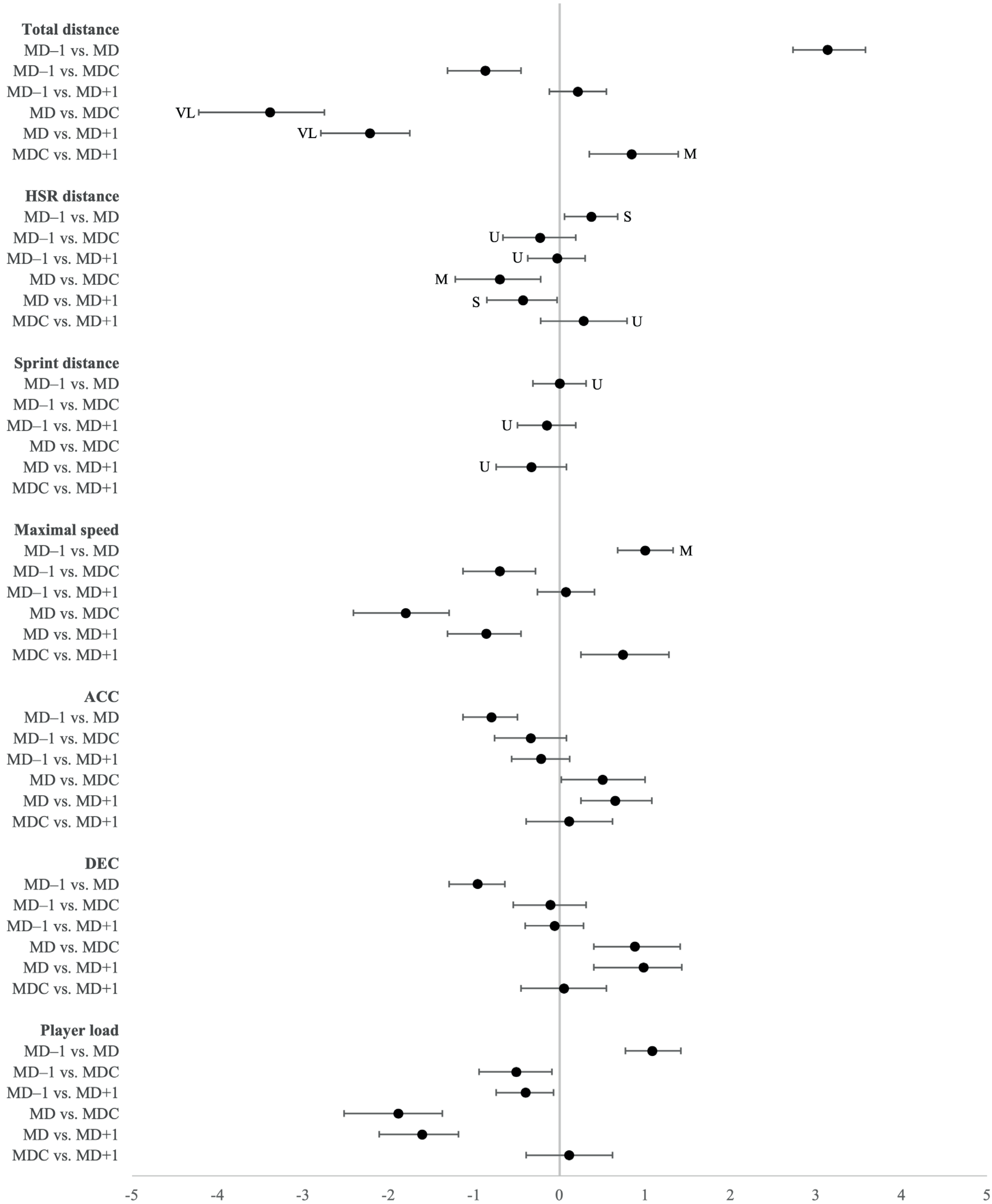
Day	Total distance (m)	HSR (m)	Sprint (m)	Maximal speed (km/h)	ACC > 3 $m.s^{-2}$ (n)	DEC < −3 $m.s^{-2}$ (n)	Player load (a.u.)
MD-1 (n = 170)	2601.04 ± 692.82	2.82 ± 11.63	1.69 ± 9.49	18.21 ± 3.95	26.41 ± 13.84	24.36 ± 11.78	33.11 ± 9.66
MD (n = 53)	5034.07 ± 999.17	7.10 ± 11.62	1.73 ± 4.76	22.16 ± 3.98	16.36 ± 6.45	13.96 ± 6.93	43.27 ± 8.27
MDC (n = 25)	2008.90 ± 552.80	0.29 ± 1.46	–	15.54 ± 2.78	21.64 ± 16.22	22.96 ± 14.80	28.31 ± 6.80
MD+1 (n = 43)	2766.51 ± 1033.55	2.44 ± 9.59	0.42 ± 2.74	18.50 ± 4.50	23.35 ± 14.31	23.65 ± 12.54	29.26 ± 9.09
All (n = 291)	3017.75 ± 1257.24	3.33 ± 10.96	1.37 ± 7.61	18.74 ± 4.32	23.72 ± 13.61	22.24 ± 12.08	33.98 ± 10.23

Note: MD-1 – day before the matchday, MD – matchday, MDC – compensatory session on the matchday, MD+1 – day after the matchday, n – number of files, HSR – high-speed running, ACC – acceleration, DEC – deceleration

Table 2. Independent mean differences [95% CI] with effect sizes [95% CI] between days for each variable

Days	Total distance	HSR distance	Sprint distance	Maximal speed	ACC > 3 m.s−2	DEC < −3 m.s−2	Player load
MD−1 vs MD	2433.03 [2192.48, 2673.58]	4.28 [0.67, 7.88]	0.04 [−2.63, 2.70]	3.96 [2.73, 5.19]	−10.05 [−13.93, −6.18]	−10.40 [−13.76, −7.04]	10.17 [7.27, 13.07]
Effect size (d)	3.13 [2.73, 3.58]VL	0.37 [0.06, 0.68]S	0.00 [−0.31, 0.31]U	1.00 [0.68, 1.33]M	−0.80 [−1.13, −0.49]M	−0.96 [−1.29, −0.64]M	1.08 [0.77, 1.42]M
p value	p < 0.001	p = 0.020	p = 0.979	p < 0.001	p < 0.001	p < 0.001	p < 0.001
MD−1 vs MDC	−592.14 [−875.15, −306.13]	−2.53 [−7.14, 2.07]	–	−2.67 [−4.28, −1.05]	−4.77 [−10.75, 1.21]	−1.40 [−6.55, −3.75]	−4.79 [−8.74, −0.84]
Effect size (d)	−0.87 [−1.31, −0.45]M	−0.23 [−0.66, 0.19]U	–	−0.70 [−1.13, −0.28]M	−0.34 [−0.76, 0.08]U	−0.11 [−0.54, 0.31]U	−0.51 [−0.94, −0.09]S
p value	p < 0.001	p = 0.279	–	p = 0.001	p = 0.117	p = 0.593	p = 0.018
MD−1 vs MD+1	165.47 [−94.54, 425.48]	−0.38 [−4.17, 3.41]	−1.28 [−4.16, 1.61]	0.30 [−1.07, 1.66]	−3.06 [−7.75, 1.63]	−0.71 [−4.72, 3.31]	−3.84 [−7.06, −0.63]
Effect size (d)	0.21 [−0.12, 0.55]U	−0.03 [−0.37, 0.30]U	−0.15 [−0.49, 0.19]U	0.07 [−0.26, 0.41]U	−0.22 [−0.56, 0.12]U	−0.06 [−0.40, 0.28]U	−0.40 [−0.74, −0.07]S
p value	p = 0.211	p = 0.843	p = 0.385	p = 0.670	p = 0.199	p = 0.729	p = 0.019
MD vs MDC	−3025.17 [−3451.83, −2598.51]	−6.81 [−11.47, −2.15]	–	−6.63 [−8.39, −4.87]	5.28 [0.18, 10.38]	9.00 [4.12, 13.88]	−14.96 [−18.74, −11.17]
Effect size (d)	−3.39 [−4.22, −2.75]VL	−0.70 [−1.22, −0.22]M	–	−1.80 [−2.41, −1.29]L	0.50 [0.02, 1.00]S	0.88 [0.40, 1.41]M	−1.89 [−2.52, −1.37]L
p value	p < 0.001	p = 0.005	–	p < 0.001	p = 0.043	p < 0.001	p < 0.001
MD vs MD+1	−2267.56 [−2681.05, −1854.07]	−4.66 [−9.04, −0.28]	−1.31 [−2.93, 0.31]	−3.66 [−5.38, −1.94]	6.99 [2.63, 11.35]	9.69 [5.68, 13.70]	−14.01 [−17.53, −10.49]
Effect size (d)	−2.22 [−2.79, −1.75]VL	−0.43 [−0.85, −0.03]S	−0.33 [−0.74, 0.08]U	−0.86 [−1.31, −0.45]M	0.65 [0.25, 1.08]M	0.98 [0.57, 1.43]M	−1.61 [−2.11, −1.18]L
p value	p < 0.001	p = 0.037	p = 0.113	p < 0.001	p = 0.002	p < 0.001	p < 0.001
MDC vs MD+1	757.61 [311.03, 1204.19]	2.15 [−1.71, 6.02]	–	2.97 [0.98, 4.96]	1.71 [−5.84, 9.26]	0.69 [−6.04, 7.42]	0.95 [−3.23, 5.13]
Effect size (d)	0.84 [0.35, 1.39]M	0.28 [−0.22, 0.79]U	–	0.74 [0.25, 1.28]M	0.11 [−0.39, 0.62]U	0.05 [−0.45, 0.55]U	0.11 [−0.39, 0.62]U
p value	p = 0.001	p = 0.270	–	p = 0.004	p = 0.653	p = 0.838	p = 0.652

Note: MD−1 – day before the matchday, MD – matchday, MDC – compensatory session on the matchday, MD+1 – day after the matchday, HSR – high−speed running, ACC – acceleration, DEC – deceleration, VL – very large effect size, L – large effect size, M – moderate effect size, S – small effect size, U – unclear effect size
Since players did not perform sprint distance during MDC, no comparisons were available with that day.



MD−1 – day before the matchday, MD – matchday, MD+1 – day after the matchday, HSR – high-speed running, ACC – acceleration, DEC – deceleration, VL – very large effect size, L – large effect size, M – moderate effect size, S – small effect size, U – unclear effect size

Figure 1. Effect sizes with 95% CI of the independent mean differences between days for each variable

Discussion

Our study analyzed the external load demands of football GKs during different days of the training week. We focused our analysis on a novel approach, the days surrounding the match, including a compensatory session on MD for goalkeepers who did not play in the match. Considering the importance of ensuring proper balance between the training and match load to reduce injury risk and of increasing match preparedness [23–25], we found that before the match (MD−1), GKs showed smaller loads in total distance, HSR distance, maximal speed, and player load, but not in sprint distance (unclear differences) and the number of ACC and DEC (higher on MD−1 with moderate effect sizes), a characteristic of managing the load distribution across the training week [7]. Similarly, MD also presented higher loads than the compensatory sessions, except for sprint distance (unclear differences) and the number of ACC and DEC (higher on MDC and MD+1 with moderate effect sizes). Increasingly, we also found that the compensatory sessions differed between them, with goalkeepers reaching higher speeds and covering longer distances during MD+1 in comparison with MDC. Moreover, we also found an absence of sprint distances during MDC. This can be justified by the type of drills performed by GKs during MDC, which may prevent GKs from reaching higher speeds.

We found that the total distance covered on MD (5034 m) was significantly greater than on other days. While this could represent a lack of preparedness of GKs to match demands, it is important to notice that GKs cover significantly shorter distances than outfield players [7]. With that in mind, according to our findings, compared to other variables, total distance may play a diminishing role on the load imposed on GKs. Moreover, this MD distance is between values reported by previous studies (4730 m and 5611 m) [8, 26]. Increasingly, MDC presented the shorter distance covered (Table 2), which may be related with the objective of this session and time available, especially in away matches where the team may have a specific schedule for the journey back home. Importantly, the distance covered at high intensities (HSR and sprint) was always inferior to 10% of the total distance, regardless of the session (Table 1), highlighting the pertinence of assessing high-speed displacements in GKs, rather than solely focusing on the total distance variable. For instance, a previous study reported that GKs covered 73% of the total distance with speeds between 0.4 to $\leq$ 12 $km{\cdot}h^{-1}$ [26]. Similar to a previous study [27], we found that GKs covered longer distances at HSR intensities during MD, which can be justified by the need to quickly respond to game situations [28]. Of note is that during the MDC session, GKs covered shorter HSR distances and failed to reach sprint intensities, showing that this session can be optimized by incorporating high-speed displacements if the goal is to better mimic match demands.

Although previous research has highlighted the importance of chronically exposing players to high-intensity displacements to ensure preparedness to the match demands [23, 24], the sessions MD−1 and MD+1 provided similar stimulus of HSR (small effect sizes) and sprint (unclear effect sizes) to the match demands. Furthermore, this work can also be performed during other training sessions, where specific exercises, such as integrated drills, can request that GKs reach higher speeds [29]. Importantly, due to the particularities of the position, GKs usually have little to no exposure to sprint distances in a 7-day microcycle [10]. One additional constraint of this may be the relation between maximal speeds and absolute thresholds. Specifically, we registered mean maximal speeds lower than the most common sprint threshold (> 25.2 km/h) [30], which highlights the characteristics of the position. Nevertheless, the lowest maximal speed was reported during MDC, with a large (effect size) difference compared to the competition (Table 2), indicating that this session did not mimic MD in this specific variable. However, it is important to notice that GKs usually cover short distances at high speeds, leading practitioners to focus on other locomotor activities such as ACC and DEC.

Contrasting to displacements, the number of ACC and DEC was lower during MD in comparison with the included training sessions, similar to a previous study [8]. This can represent that GKs regularly perform more ACC (> 3 $m{\cdot}s^{-2}$) and DEC (< −3 $m{\cdot}s^{-2}$) during training sessions close to MD than during the competition itself. However, we found a higher player load during MD in comparison with the other sessions, especially with the compensatory sessions (MDC and MD+1), where large effect sizes were registered. These findings may seem contradictory, but it is important to recognize the limitations of using absolute and arbitrary thresholds when evaluating ACC and DEC demands [31]. For instance, arbitrary thresholds may not accurately reflect GK's demands, as they overlook individual and positional characteristics. An individualized approach could yield different outcomes. Player load, on the other hand, serves as a key variable for accurately assessing a GK match demands, as it accounts for movement across multiple planes [14]. In contrast, intense horizontal ACC and DEC may occur less frequently during competition.

However, their frequency can vary depending on team strategies, highlighting the need for further research. Our findings oppose the ones found by a previous study [32], where the player load was significantly higher during MD+1 than during MD−1. However, since that study only reported data from training sessions, it is difficult to perceive if the reported values differed between training and competition.

Notably, this does not devalue the importance of assessing ACC and DEC demands in GKs. While during specific moments or activities GK may need to perform quick displacements to reach the ball before the opposition [1, 29], those movements appear to be with short distances [8], underlining the importance of performing intense ACC and DEC. Moreover, previous research stated the importance of preparing players by managing the load, and consequently reducing the injury risk [33].

By focusing our analysis on the days close to MD, we provided a novel approach regarding the match preparedness and compensation. However, the remaining sessions could sustain, that the load distribution of GKs differs from other positions [7]. Moreover, the widely discussed limitations of arbitrary and absolute thresholds [30, 31, 34] may also impact our findings. Specifically, considering the maximal speeds reported, it appears crucial to provide a relative sprint threshold to properly assess high-intensity displacements of GKs. Finally, our findings are specific to a particular context, and caution should be exercised when applying these results to different settings. This is especially important given the differences we observed compared to previous research. Variations in playing style, tactical approaches, and individual player characteristics may all influence the outcomes, underscoring the need for further studies to explore how these factors interact across different teams and competitive levels.

When discussing the preparation of GKs, we observed a particular dynamic. While during MD−1, the primary focus was on minimizing fatigue to ensure players were physically and mentally prepared for the competition [7], GKs performed more ACC and DEC in this session than during the game itself. This phenomenon underlines the specifics of the position [1, 35], and the need to consider specific strategies. That is, with GKs, practitioners may need to focus on the development of their player's capacities as a sudden increase in match load is unexpected. On the other hand, the compensatory sessions provide lower loads regarding displacements (total distance, HSR distance, and sprint distance), maximal speeds, and player load. However, since GKs are exposed to lower match loads than outfield players [7, 31], practitioners can differ in their approach for load management. Comparing MDC and MD+1 requires careful attention, as they involve different loads which reflect different approaches. First, teams may face time constraints when managing load distribution around the match day. For instance, if a team has the day off after competition, a compensatory session would be important during MD. Second, during the MDC session, practitioners might face specific limitations, leading to lower distances covered and no sprints. As a result, the load distribution will vary depending on the compensatory session choice (MDC vs MD+1). Finally, considering the expected lower loads for this position, compensatory sessions can be treated as regular training sessions aimed at balancing the weekly load and preventing overloading in other sessions, which could negatively affect the players [25]. Even so, if practitioners chose the MDC session, GKs would need to receive stimulus to reach higher speeds and cover sprint distances during the training week.

Conclusions

Our study showed that the load management near competition in GKs differs from the traditional approaches towards outfield players. By evaluating the total distances covered, HSR distances, sprint distances, maximal speeds, the number of ACC and DEC, and player load during the training week and MD, we assessed the differences between MD−1, MD, MDC (compensatory session during MD), and MD+1. During MD, players covered higher distances (total and at HSR), reached higher maximal speeds and presented higher player load values in comparison with other training sessions. However, the lowest number of ACC and DEC were registered during MD. Notably, MD+1 and MDC, which typically involve compensatory strategies, showed similar demands, except for total distance, sprint distance (which was absent in MDC), and maximal speed (which was higher on MD+1). Our findings highlight the need for a tailored load distribution approach for GKs throughout the week.

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Conflict of Interest

The authors declare no conflict of interest.

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