



Greater Goal Difference is Associated with Lower Physical Demands in Cerebral Palsy Football Referees

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Abstract

This study examines the association between match outcome variables, total goals, goal difference, and the physical demands placed on referees in cerebral palsy (CP) football. Thirteen international referees were monitored via global positioning devices during 42 official matches at the 2022 CP Football World Cup and World Championships. Physical demands, including distances covered at various speeds and acceleration/deceleration metrics, were analyzed. Results revealed moderate to high negative correlations between goal difference and total, explosive, walking, jogging, medium-intensity running, high-intensity running and sprinting distances; maximum speed, accelerations, low intensity acceleration in zones 1 and 2, low intensity deceleration in zones 1 and 2, and player load ($p = -0.30$ to -0.54 ; $p < 0.001$ to 0.04). In contrast, total goals showed only isolated, moderate correlations with medium-intensity running distance and deceleration Z1 ($p = -0.33$; $p < 0.03$ to 0.04). These findings indicate that match competitiveness, reflected by the goal difference, is a key factor associated with referees' physical workload in CP football, with closer matches eliciting higher physical demands on the referees. The results highlight the importance of considering match context in referees' training, recovery management, and match allocations, ensuring they are adequately prepared for the high demands of closely contested matches and can recover effectively during international-level CP football competitions.

Keywords: soccer, contextual factors, performance, external load, officials



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Introduction

People with cerebral palsy (CP) live with a lifelong prevalent physical disability, characterized by heterogeneous conditions that impact participation in para-sports at different

competitive levels (Romeo et al., 2024). Many individuals with CP participate in CP football, a competitive format designed for para-athletes with mild motor impairments (GMFCS I–II), such as spastic hypertonia, ataxia, or dyskinesia (Hen-

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riquez et al., 2023; Reina et al., 2020). The professionalization of para-sports has increased research interest in the performance factors of both para-athletes and referees (Bao et al., 2025). However, while much of the research has focused on para-footballers with CP or related neurological conditions, there is still limited information regarding the referees who officiate football matches for para-athletes with CP (Henríquez, Ozaeta, et al., 2024). Specifically, CP football shares the fundamental characteristics of conventional football, requiring a range of motor skills and high-intensity efforts during key moments of play (Castillo et al., 2025). However, it is contested in a seven-a-side format on a reduced-size pitch (usually 70 × 50 m), with a standard men's match consisting of two 30-min halves separated by a 10-min break. In the event of a draw at the end of regular time, two extra periods of 15 min are played, with a 5-min break before the first extra period and no resting interval between them (International Federation of Cerebral Palsy Football, 2023).

From a physical and physiological perspective, refereeing is an intermittent activity that predominantly relies on the aerobic system, with occasional actions of high-intensity effort in which the anaerobic system is interspersed (Castagna et al., 2007). Referees in CP football officiate matches that follow specific adaptations of standard football rules (i.e., smaller field size, lower number of players, no offside rule, shorter match time) that favor the participation of players categorized based on the impact of the eligible coordination impairments (Peña-González et al., 2022). Even with these match modifications, previous research shows that CP football referees face substantial physical demands, covering on average more than 5700 m per match, including over 900 m at moderate intensity and more than 150 m at high to maximal sprinting intensity (Henríquez, Ozaeta, et al., 2024). Despite the relatively short duration of these high-speed efforts, referees perform an exceptionally high number of rapid speed changes with around 1800 accelerations and 1850 decelerations per match, underscoring the intense and intermittent nature of officiating in CP Football (Henríquez, Ozaeta, et al., 2024). Since there is only one study that has examined these demands, further research is needed to provide stronger and more comprehensive evidence regarding these demands.

CP football referees officiate a sport with a higher number of goals per match compared to regular football, likely due to the specific technical and tactical characteristics of this discipline (Castagna et al., 2007; Henríquez, Reina, et al., 2024; Peña-González et al., 2022). As in regular football, the physical demands placed on players can vary according to contextual factors such as the level of opposition and final outcomes, although this remains unknown in the context of CP football referees (Henríquez, Reina, et al., 2024). Referee decisions have a substantial impact on match outcomes, highlighting the importance of understanding the physical demands they face (Castagna et al., 2007). Therefore, this study aimed to analyze the association between match outcome variables (i.e., total goals and goal difference) and the physical demands (i.e., distances covered at different intensities, accelerations and decelerations) of CP football referees, during international-level official matches. The main hypothesis is that a higher number of total goals and a greater goal difference will be associated with lower physical demands in terms of distance covered at different intensities and lower acceleration/deceleration variables in CP football referees.

Methods

Participants

This study analyzed 13 international referees (10 men and 3 women; age: 39.17 ± 8.26 yr; weight: 76.07 ± 13.39 kg; height: 174.04 ± 9.97 cm; body mass index: 24.99 ± 3.28 kg/m²) from 11 nationalities who voluntarily participated in this study. The participants officiated matches during two 2022 world competitions for men's CP football and had 18.62 ± 9.24 yr of refereeing experience in regular football and 6.54 ± 4.22 yr of refereeing in CP football. All referees were fully informed of the study protocols and provided written informed consent to participate. The study received ethical approval from a university Ethics Committee (reference no. DPS.RRV.03.17).

Procedures

A correlational study design was used to examine the associations between match outcome variables (total goals [TG] and final goal difference between teams [GD]) with the referees' match physical demands. Data was collected from 42 official CP football male international-level matches (i.e., 1 minimum and 5 maximum observations per referee) played between 09:00 to 18:00 hours in the 2022 men's CP Football world competitions (i.e., World Cup and World Championships) held at sea level in Catalonia region (Spain). Matches that went into extra time were considered, but only data from the regular two extra periods were analyzed. All referees wore vests fitted with global positioning system (GPS) devices to monitor the physical demands in matches conducted on an artificial turf field with official CP football dimensions. Prior to the matches, participants abstained from engaging in any strenuous physical activity and completed a 15-minute warm-up established by the head referee.

Measures

The match outcome variables analyzed were TG, representing the total number of goals achieved by both teams at the end of the match; and GD, defined as the absolute difference in goals between the two teams at the end of the match. These data were obtained from the official match reports of the games analyzed and publicly available (<https://www.ifcpf.com/>). Match running performance was assessed using WIMU PRO™ devices (RealTrack Systems SL, Almería, Spain) using GPS technology, with a sampling frequency of 10 Hz. The validity and reliability of these devices for evaluating physical demands have been previously established (Bastida-Castillo et al., 2018) and have also been used in CP football referees (Henríquez, Ozaeta, et al., 2024). Prior to each match (i.e., 15 min before the warm-up), the GPS units were activated and synchronized following the manufacturer's guidelines. Data were extracted and processed using SPRO™ software (RealTrack Systems SL, Almería, Spain) after the end of each match.

The variables analyzed in this study included the total distance covered, explosive distance (distance covered with accelerations > 1.12 m/s²), maximum speed (km/h), and distance covered at various speed thresholds: walking (0–6 km/h), jogging (6–12 km/h), medium-intensity running (MIR: 12–18 km/h), high-intensity running (HIR: 18–21 km/h), sprinting (21–24 km/h), and maximum sprinting (> 24 km/h) (Gamonal et al., 2022; Henríquez, Ozaeta, et al., 2024). Additionally, high-intensity braking distance (HIBD; distance with deceleration > 2 m/s²), high-speed running actions (HSRA; > 21 km/h) and number of sprints (n) metrics were also included (Lago-Peñas et al., 2024; Mara et al., 2017). These absolute speed thresholds were selected

as they represent the default configuration of the WIMU PRO™ software and have been previously utilized in elite conventional football contexts, such as the Spanish LaLiga (Lago-Peñas et al., 2024). The total number of accelerations and decelerations, defined as any change in velocity crossing the zero axis, was recorded alongside the maximal acceleration (ACC_{max}: m/s²) and maximal deceleration (DEC_{max}: -m/s²) (Martin-Sanchez et al., 2022). The distance covered while accelerating and decelerating was classified based on the intensity of these actions into four zones: Zone 1 (distance accelerating/decelerating: 0–1 m/s²), Zone 2 (distance accelerating/decelerating: 1–2 m/s²), Zone 3 (distance accelerating/decelerating: 2–3 m/s²), and Zone 4 (distance accelerating/decelerating: > 3 m/s²). (Oliva-Lozano et al., 2021). Finally, the player load was used and represented in arbitrary units (Reche-Soto et al., 2019).

Statistical analysis

Descriptive statistics data were presented using sample size, means, standard deviations, minima and maxima. Normality and homoscedasticity of data distribution were tested using the Shapiro–Wilk and Levene tests. The Shapiro–Wilk test indicated that the variables TG and GD did not follow a normal distribution;

consequently, the associations between physical match demands and match outcome variables were calculated using Spearman's Rank Correlation Coefficient (ρ). The following scale was used to interpret the magnitudes of the correlations: less than 0.1, trivial; from 0.1 to 0.3, low; from 0.3 to 0.5, moderate; from 0.5 to 0.7, high; 0.7–0.9, very high; and greater than 0.9, almost perfect (Hopkins et al., 2009). The data analysis was carried out using JASP (JASP for Windows, version 0.17, Amsterdam, Netherlands). Statistical significance was set at $p < 0.05$.

Results

Descriptive statistics for match variables and referees' physical demands metrics across the 42 analyzed matches are presented in Table 1. The matches were characterized by a high-scoring nature, with TG averaging 5.19 ± 3.41 and a mean GD of 3.67 ± 3.84 . Regarding physical demands, referees covered a Total Distance of 5026.45 ± 1265.00 m per match. The distance was predominantly covered at lower intensities, with Walking and Jogging constituting the largest portions at 2407.14 ± 283.27 m and 1709.26 ± 659.43 m, respectively. The number of accelerations and decelerations per match were 1754.81 ± 137.05 and 1764.21 ± 133.36 , respectively.

Table 1. Descriptive statistics of match and physical variables of referees in cerebral palsy football ($n = 42$)

	Mean	SD	Minimum	Maximum
Match variables				
Total goals (n)	5.19	3.41	0.00	16.00
Goal difference (n)	3.67	3.84	0.00	16.00
Physical variables				
Total distance (m)	5026.45	1265.00	2386.70	6416.70
Explosive distance (m)	367.35	182.38	46.70	732.50
Walking distance (m)	2407.14	283.27	1823.30	3116.50
Jogging distance (m)	1709.26	659.43	498.70	2774.10
Medium-intensity running (m)	755.81	414.79	64.70	1626.30
High-intensity running (m)	99.79	81.59	0.00	263.30
Sprinting (m)	38.82	50.57	0.00	173.70
Maximum sprinting (m)	15.63	36.61	0.00	190.40
HIBD (m)	62.08	48.78	2.99	170.22
Sprints (n)	1.33	2.65	0.00	10.00
HSRA (n)	4.21	5.34	0.00	18.00
Maximum speed (km/h)	21.47	3.42	14.96	28.59
Accelerations (n)	1754.81	137.05	1457.00	1974.00
Decelerations (n)	1764.21	133.36	1481.00	1987.00
ACC _{max} (m/s ²)	7.27	1.18	4.93	10.16
Accelerations Z1 (n)	1253.62	250.79	840.54	1860.63
Accelerations Z2 (n)	886.96	315.29	169.00	1294.40
Accelerations Z3 (n)	336.01	210.94	11.90	867.16
Accelerations Z4 (n)	73.64	72.57	0.00	276.19
DEC _{max} (m/s ²)	-7.81	1.47	-11.45	-4.69
Decelerations Z1 (n)	1307.71	241.60	856.41	1748.61
Decelerations Z2 (n)	848.40	315.38	166.00	1269.96
Decelerations Z3 (n)	257.08	157.42	24.00	624.75
Decelerations Z4 (n)	81.42	78.97	0.00	326.43
Player Load (AU)	48.24	21.55	8.63	99.29

Note. SD: standard deviation; HIBD: high-intensity braking distance; HSRA: high-speed running actions; ACC_{max}: maximum acceleration; DEC_{max}: maximum deceleration.

The associations between TG or GD and physical variables related to distance covered at different intensities are presented in Table 2. Several significant negative correlations were observed between GD and physical demands. Specifically, greater GD was significantly associated with lower values of referees Total Distance ($\rho = -0.52$; $p < 0.001$; high), Explosive Distance ($\rho = -0.36$; $p = 0.02$; moderate), Walking ($\rho = -0.32$; $p = 0.04$; moderate), Jogging ($\rho = -0.54$; $p < 0.001$; high), MIR

($\rho = -0.48$; $p < 0.001$; moderate) and HIR ($\rho = -0.37$; $p = 0.02$; moderate). Additionally, sprints ($\rho = -0.30$; $p = 0.04$; moderate) and maximum speed ($\rho = -0.47$; $p < 0.001$; moderate) were also correlated with GD. No associations were observed between GD and Sprinting, HIBD or HSRA. No significant correlations were found between TG and any of the physical demands variables ($\rho = -0.11$ to -0.29 ; $p > 0.05$), except for MIR ($\rho = -0.33$; $p = 0.04$; moderate).

Table 2. Associations between Total Goals and/or Goal Difference and physical response variables by referees in cerebral palsy football matches related to the total distance

Variables	TG			GD		
	ρ	CI (95%)	p value	ρ	CI (95%)	p value
Total distance (m)	-0.29	(-0.54, 0.00)	0.06	-0.52†	(-0.70, -0.27)	0.00
Explosive distance (m)	-0.11	(-0.49, 0.03)	0.25	-0.36*	(-0.58, -0.09)	0.02
Walking distance (m)	-0.28	(-0.55, 0.02)	0.07	-0.32*	(-0.56, -0.02)	0.04
Jogging distance (m)	-0.26	(-0.51, 0.05)	0.10	-0.54†	(-0.74, -0.29)	0.00
MIR (m)	-0.33*	(-0.56, -0.04)	0.04	-0.48†	(-0.67, -0.22)	0.00
HIR (m)	-0.25	(-0.50, 0.06)	0.11	-0.37*	(-0.60, -0.07)	0.02
Sprinting (m)	-0.13	(-0.42, 0.18)	0.40	-0.25	(-0.52, 0.06)	0.11
Maximum sprinting (m)	-0.19	(-0.47, 0.10)	0.23	-0.31*	(-0.57, 0.00)	0.04
HIBD (m)	-0.15	(-0.41, 0.15)	0.35	-0.24	(-0.48, 0.01)	0.12
Sprints (n)	-0.18	(-0.46, 0.12)	0.25	-0.30*	(-0.57, 0.00)	0.04
HSRA (n)	-0.17	(-0.46, 0.12)	0.28	-0.26	(-0.52, 0.03)	0.10
Maximum speed (km/h)	-0.15	(-0.44, 0.18)	0.34	-0.47†	(-0.70, -0.19)	0.00

Note. TG: total goals; GD: goal difference; ρ : Spearman's rank correlation coefficient; CI: confidence interval; MIR: medium-intensity running; HIR: high-intensity running; HIBD: high-intensity braking distance; HSRA: high-speed running actions; * $p < 0.05$; † $p < 0.01$.

The associations between TG or GD and physical variables related to accelerations, decelerations and/or Player Load are presented in Table 3. Several significant correlations were observed between GD and physical demands variables. Specifically, greater GD was associated with lower values in accelerations ($\rho = -0.32$; $p < 0.04$; moderate), low-intensity

accelerations in zones 1 and 2 ($\rho =$ from -0.47 to -0.50 ; $p < 0.001$; moderate), low-intensity decelerations in zones 1 and 2 ($\rho =$ from -0.49 to -0.53 ; $p < 0.001$; moderate to high), and Player Load ($\rho = -0.50$; $p < 0.001$; moderate). Other physical variables related to accelerations or decelerations, including ACCmax, accelerations in zones 3 and 4, number of decel-

Table 3. Associations between Total Goals and/or Goal Difference and accelerations, decelerations, maximal acceleration, maximal deceleration, distance covered accelerating and decelerating at different speeds, and player load

Variables	TG			GD		
	ρ	CI (95%)	p value	ρ	CI (95%)	p value
Accelerations						
n	-0.23	(-0.52, 0.09)	0.15	-0.32*	(-0.58, 0.00)	0.04
ACCmax (m/s ²)	-0.01	(-0.31, 0.29)	0.97	-0.03	(-0.31, 0.28)	0.85
Zone 1 (m)	-0.30	(-0.56, 0.00)	0.06	-0.47†	(-0.67, -0.18)	0.00
Zone 2 (m)	-0.23	(-0.54, 0.11)	0.14	-0.50†	(-0.73, -0.22)	0.00
Zone 3 (m)	-0.18	(-0.44, 0.12)	0.26	-0.30	(-0.52, -0.03)	0.05
Zone 4 (m)	-0.09	(-0.37, 0.20)	0.57	-0.19	(-0.44, 0.09)	0.23
Decelerations						
n	-0.22	(-0.51, 0.11)	0.16	-0.28	(-0.55, -0.04)	0.07
DECmax (-m/s ²)	0.07	(-0.23, 0.35)	0.65	-0.09	(-0.20, 0.36)	0.59
Zone 1 (m)	-0.33*	(-0.60, 0.01)	0.03	-0.53†	(-0.71, -0.27)	0.00
Zone 2 (m)	-0.22	(-0.51, 0.11)	0.16	-0.49†	(-0.73, -0.23)	0.00
Zone 3 (m)	-0.16	(-0.43, 0.12)	0.31	-0.29	(-0.52, -0.04)	0.06
Zone 4 (m)	-0.16	(-0.44, 0.12)	0.32	-0.14	(-0.39, 0.15)	0.39
Player Load (AU)	-0.13	(-0.43, 0.17)	0.41	-0.50†	(-0.71, -0.20)	0.00

Note. TG: total goals; GD: goal difference; ρ : Spearman's rank correlation coefficient; CI: confidence interval; * $p < 0.05$; † $p < 0.01$.

erations, DECmax and decelerations in zones 3 and 4 were not correlated with GD ($p > 0.05$). No significant correlations were found between TG and any physical demands variables related to accelerations or decelerations ($\rho = -0.01$ to -0.23 ; $p > 0.05$) except for deceleration in zone 3 ($\rho = 0.33$; $p = 0.03$; moderate).

Discussion

The results of the present study suggest a limited association between the competitive context of the matches, specifically GD, and the physical demands of referees in CP football at international-level matches. While the total number of goals showed only isolated, moderate negative correlations with MIR and low-intensity decelerations, moderate to high negative associations were observed between GD and multiple physical demands variables, such as Total Distance, distances covered at different intensities (ranging from Walking to HIR), as well as variables related to accelerations, decelerations and Player Load. Although no studies have been found examining how match outcome may influence the physical demands of CP football referees, scientific literature has analyzed the influence of match outcome on regular football players' and referees' physical demands (Fan et al., 2025; Jerkovic et al., 2022; O'Donoghue & Tenga, 2001). Hence, this represents the first study that analyzes the association between match outcome and the physical demands of CP football refereeing.

Previous research has shown that the total number of goals scored in CP football matches tends to be higher than in regular football matches, which may have implications for the physical demands experienced by players and referees officiating the competition (Henríquez, Ozaeta, et al., 2024; Peña-González et al., 2022). According to the CIES Football Observatory 40th report, the average goal difference per match across European leagues is approximately 1.34 goals (Poli et al., 2018), in contrast, the results of the present study revealed a substantially larger value in CP football, with a mean goal difference of 3.67 goals. This markedly greater competitive imbalance may reflect structural and functional differences in team composition, dynamics, and match physical demands between CP and regular football (Peña-González et al., 2022). The competitive level of national teams can vary substantially depending on each country's resources, structures for para-athletes development, and investment in para-sport programs (Dehghansai et al., 2022). As a result, nations with more established talent identification systems, better training environments, and greater economic support tend to field higher-level players, whereas countries with fewer resources may present less experienced or less physically prepared athletes (Peña-González et al., 2025).

The results of the present study suggest that GD is meaningfully associated with the physical demands of referees in CP football. Specifically, larger GD was associated with reduced total distance covered, shorter distances at different running intensities, and lower values for explosive distance, sprinting actions, and maximum speed. These results align with findings reported by (Fan et al., 2025) in professional Chinese Super League referees, who exhibited greater total distance, high-speed running, and sprinting activity during matches that finished in a tie. In balanced matches, gameplay tends to be faster and more chaotic, with numerous counterattacks, individual duels, and possession turnovers, forcing

referees to respond with constant positional adjustments, including accelerations and decelerations (Aquino et al., 2021). Matches that are more evenly contested are associated with higher physical demands (Buchheit et al., 2018; Jerkovic et al., 2022; O'Donoghue & Tenga, 2001); therefore, in matches with a larger GD, players' physical demands are likely reduced, and consequently, referees' responses, which are influenced by players' activity levels (Weston et al., 2011; Zhou et al., 2025), would also be lower.

Nevertheless, certain differences emerge between regular football and CP football. While Fan et al. (2025) observed increased running performance in matches with wide score margins (≥ 2 goals), possibly due to a more open and less structured game dynamic, the opposite trend was observed in the present study. According to the results of the present study, referees' physical demands in CP football progressively decreased as the GD increased, suggesting that once the outcome of a match becomes evident, the pace and tactical intensity decline markedly. This difference likely reflects the specific nature of CP football. The high competitive imbalance (mean goal difference = 3.67) and diverse player profiles may reduce match intensity once a team takes a clear lead. Consequently, CP football referees appear to adjust their positioning less frequently and to cover smaller areas of the pitch, resulting in a lower overall workload compared with matches that remain competitive until the final minutes.

Regarding variables related to accelerations and decelerations, negative associations were identified between GD and the total number of accelerations, as well as low-to-medium intensity accelerations and decelerations (zones 1 and 2). Once again, these patterns can be explained by a reduced need to closely follow the game when the match outcome is practically decided. Referees may perform fewer total movements but still engage in bursts of high-intensity accelerations, possibly for positioning during counterattacks or to maintain offside-line awareness. In situations where one team clearly dominates, the competitive pace tends to drop (Buchheit et al., 2018; Jerkovic et al., 2022; Redwood-Brown et al., 2018), which appears to be associated with lower referees' physical demands. In contrast, in regular football, referees tend to increase their physical demands when the GD exceeds two goals (Fan et al., 2025). However, GD between winning and losing teams is generally larger in CP football, so such situations are less common compared to regular football. Moreover, such GD in regular football is often reached near the end of the match, thus influencing only a small portion of the match (Redwood-Brown et al., 2012).

On the other hand, it is worth noting that only two significant correlations were observed between the total number of goals and the referee's physical demands variables (specifically, with MIR and low-intensity decelerations), while the vast majority showed no association. This confirms that referee physical demands are more strongly associated with goal difference than with total goals (Buchheit et al., 2018), reflecting the impact of match competitiveness and scoreline uncertainty. In a match where both teams score many goals but maintain a close score, the physical demands on the referee may be even greater than in a low-scoring match with a clear imbalance, reinforcing the relevance of contextual factors that can interact in a game (Henríquez, Reina, et al., 2024).

This study is not exempt of limitations that should be acknowledged when interpreting the results. First, the sample

size was relatively small ($n=13$), with an unequal distribution between genders (10 men and 3 women), which limits the ability to generalize the findings to the broader refereeing population, particularly regarding female officials. Second, the dataset includes multiple match observations from the same referee, ranging from one to five matches per official. Although the statistical analyses treated all observations as independent, this approach does not model intra-subject dependency. While linear mixed-effects models were considered to address this issue, the highly unbalanced nature of the repeated measures and relatively small cluster sizes resulted in unstable model estimations. Consequently, the reported relationships reflect these global match demands, and readers are advised to interpret the associated p -values with this methodological constraint in mind. Moreover, the data were collected exclusively during male international-level competitions, meaning it is unknown whether these physical demand patterns are applicable to female CP football or domestic leagues with different competitive levels. Methodologically, the study focused solely on external load metrics quantified via GPS devices, without monitoring internal load variables (such as heart rate or rating of perceived exertion), which would have provided a more comprehensive understanding of the physiological strain associated with varying goal differences. While match outcome variables were analyzed, other potential contextual factors that could influence physical demands were not controlled for. As referee physical demands are likely associated with numerous additional variables, future research should account for factors such as the specific match period, team quality, match importance, and specific environmental conditions to provide a more holistic understanding of officiating demands. Finally, the absolute speed thresholds utilized to categorize running intensities were based on conventional football intensities. The authors acknowledge that given the unique functional and motor characteristics of players with CP, these standard thresholds may not accurately reflect the relative physiological demands of the sport. Therefore, future research should focus on establishing and validating specific speed thresholds specifically adapted to the CP football population.

Conclusions

The results of the present study show that closely contested matches involve greater physical demands for CP football referees. This trend, documented in professional and conventional football, is also observed in CP football, suggesting that match competitiveness is a key factor associated with referees' physical demands, regardless of whether the match is in regular or CP football. These findings highlight the importance of considering match context in performance analysis and underscore the need for specific preparation to handle high-demand situations, especially in matches with uncertain outcomes. From a practical perspective, these results provide actionable insights for referee physical coaches, tournament organizers, and the referees themselves. From an applied perspective, referee training programs should replicate the specific high-intensity demands of closely contested matches—such as repeated sprints, rapid changes of direction, and explosive accelerations—to minimize fatigue-related errors. Furthermore, from an organizational standpoint, refereeing committees must consider these findings when making match appointments during demanding international tournaments. Specifically, organizers should strategically rotate officials by

considering whether a referee has recently officiated a closely contested match, as the associated physical demands may require longer recovery periods. Consequently, recovery strategies must be individualized, ensuring that referees involved in high-stress, narrow-margin matches receive more intensive regeneration protocols before their next assignment.

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