ORIGINAL SCIENTIFIC PAPER

Does the Final Score Influence the Physical Demands of Women's Handball Matches?

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Abstract

The purpose of this study was twofold: to analyze and compare the influence of the final score of the match (close, balanced and unbalanced) on physical demands during official competitions in women's handball; and to investigate if the physical demands of each playing position are affected by the final score. Twenty-two semi-professional female players from the Spanish 2nd Division were monitored across 13 official matches. Total distance (TD), high-speed running (HSR), high-intensity braking distance (HIBD), accelerations (ACC), decelerations (DEC) and PlayerLoad (PL) were collected in absolute and relative values using a local positioning system (WIMU PRO™, Realtrack Systems S.L., Almería, Spain). Two-way ANOVA with partial Eta-squared and Cohen's d were used to determine the differences between playing positions and match types. Unbalanced (16.4±4.1 n·min^{-1}) and balanced matches (15.2±3.8 n·min^{-1}) elicited higher DEC/min than close matches (13.1±2.8 n·min^{-1}) ($p<0.001$, moderate effects). In relation to playing positions, wings covered the largest TD and registered the highest values of PL in balanced and unbalanced matches ($p<0.001$, large effects). Also, wings presented the highest values of HIBD, HSR and HSR/min regardless of the final score ($p<0.05$, moderate effects). Moreover, wings performed largely more number of ACC and DEC compared to pivots in unbalanced matches ($p<0.05$, large effects). In conclusion, this study showed that the final score of the match influences the physical demands experienced by female handball players during official competitions. This information should be considered by coaches to adapt and periodize the training load across the microcycle.

Keywords: *external load; tracking system; load monitoring; local positioning system; microsensors; wereables*

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Introduction

Handball is an intermittent team-sport characterized by high physical efforts with strenuous body contact against the opponents, interrupted by variable length periods with low-intensity movements (e.g., walking and standing still) (Karcher and Buchheit, 2014). The occurrence of these high-intensity actions is highly unpredictable, random and variable during the match (Wagner et al., 2014). Additionally, the intensity and speed of the game have increased considerably in recent years, mainly due to relatively recent changes in the rules of the game

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(e.g., throw- off not on the line but inside the center circle) and constant improvements in the tactical use of unlimited substitutions (e.g., goalkeeper substitution rule) (Hatzimanouil et al., 2024). Therefore, coaches and practitioners should analyze the physical demands encountered during official competitions to: (1) design short- and long-term training programmes to maximize performance, reduce injury risk and minimize the risk of overtraining; (2) develop and implement individualized physical training programmes for each playing position; and (3) adapt and periodize weekly training loads to manage stress and recovery (García-Sánchez et al., 2025). To achieve this purpose, technical staff can use new monitoring tools with a good level of validity (Bastida-Castillo et al., 2019) and reliability (Luteberget et al., 2018), such as local positioning system (LPS) including ultra-wideband technology (UWB) and inertial measurement units (IMUs) (e.g., accelerometer, magnetometer and gyroscope) to measure and analyze physical demands in real-time during training and competitions.

Given these technological advances, a recent systematic review indicated that elite handball players usually cover between 2000 and 4500 m per match, with high-intensity running and sprinting accounting for 5% to 15% of this distance (Michalsik et al., 2013; Michalsik et al., 2014; Póvoas et al., 2012; Póvoas et al., 2014). Nevertheless, the physical demands are highly variable due to the influence of gender, competition level, playing positions and contextual factors (García-Sánchez et al., 2023). More specifically, these researchers reported that wings covered a moderately greater total distance than backs and pivots (García-Sánchez et al., 2023). Additionally, another study showed that backs performed the highest number of high-intensity events per minute followed by pivots and then by wings (Luteberget and Spencer, 2017). Furthermore, a recent study conducted with elite female players during the European Championship 2020 showed that wing players covered higher distances in the high-intensity locomotive categories than the rest of the playing positions (Zapardiel et al., 2024).

In relation to contextual factors, previous studies conducted in other team sports (e.g. basketball, soccer or ice hockey) have shown that physical demands are highly influenced by several factors, such as match location (playing home or away) (Augusto et al., 2021; García-Unanue et al., 2018), halves of the match (first half or second half) (García-Unanue et al., 2018; Pino-Ortega et al., 2019), level of the opponent (high-level teams, intermediate-level teams or low-level teams) (Augusto et al., 2021; García-Unanue et al., 2018; Pino-Ortega et al., 2019), match outcome (win, draw or loss) (Augusto et al., 2021; Douglas et al., 2019), final score (balanced or unbalanced matches) (Alonso et al., 2023; Fox et al., 2019) and player role (starter or non-starter) (Oliveira et al., 2023). However, in handball a reduced number of studies have investigated the impact of contextual factors on the external load experienced by players (García-Sánchez et al., 2023). Most of these studies have focused on analyzing differences according to the halves of the match (Michalsik et al., 2013; Michalsik et al., 2014; Póvoas et al., 2012; Wik et al., 2017), but none have examined the impact of the goal difference at the end of the match on physical demands.

As mentioned above, evidence-based knowledge about the influence of final score on physical demands during official matches in female handball is currently limited. Therefore, the aims of this study were: (1) to analyze and compare the influence of the final score of the match (± goal difference) on physical demands during official competitions in women's handball, and (2) to investigate if the physical demands of each playing position are affected by the final score of the match.

Methods

Design

We conducted a retrospective observational design to analyze and compare the influence of the final score of the match (± goal difference) on physical demands during official competitions in women's handball. The LPS data collected correspond to the average values of 13 official home matches from the Spanish 2nd Division during the 2021–2022 season (18th September 2021 – 2nd April 2022). We excluded goalkeepers because running-based demands do not reflect their performance needs (Bassek et al., 2023; García-Sánchez et al., 2024). Also, we excluded LPS registers from field players with less than 1 minute of playing time (Wik et al., 2017).

Participants

Twenty-two semi-professional female handball players from the same team participated voluntarily in the study. Playing positions were: wings (n = 4; age: 18.8±0.5 years; height: 162.0±3.8 cm; body mass: 55.5±4.3 kg), backs (n = 14; age: 20.9±3.6 years; height: 168.7±3.9 cm; body mass: 65.4±6.8 kg) and pivots (n = 4; age: 21.0±1.8 years; height: 171.3±4.8 cm; body mass: 79.1±11.0 kg). The players belong to the third tier of competition (highly trained or national level), according to the Participant Classification Framework provided by McKay et al. (2022). During the season, players typically performed four handball training sessions and two strength training sessions per week. Also, they participated regularly in one match per week. All players were informed of the study requirements and provided written informed consent prior to the start of the study. Additionally, all the ethical procedures used in this study were in accordance with the Declaration of Helsinki (Harris & Atkinson, 2015) and were approved by the European University of Madrid Ethics Committee (CIPI/18/195).

Procedures and data analysis

All players were monitored using a local positioning system (LPS) (WIMU PRO™, RealTrack System SL, Almería, Spain) with ultra-wideband technology (UWB) and inertial measurement units (IMUs) with a good level of reliability (Bastida-Castillo et al., 2019). The LPS was installed on the official handball court where the team played their home matches according to user manual and previous studies (Font et al., 2021; Font et al., 2023; García-Sánchez et al., 2024). All players were already familiarized with the data-collection procedures during previous training sessions and friendly matches. Manufacturer's specific software (SPRO™, version 958, RealTrack System SL, Almería, Spain) was used to calculate the perimeter of the court to determine the effective playing time. In accordance with previous studies (Font et al., 2021; Font et al., 2023; García-Sánchez et al., 2024), playing time was recorded only when the players were inside the court, omitting periods when the match was interrupted (e.g. team time-outs, consultations between the referees, interruptions to wipe the court, or 2-minutes suspensions). After the match, the LPS files were exported to an USB memory and analyzed using the manufacturer's specific software. Finally, raw data were exported post-match in Excel format and imported into the statistical software for statistical analysis. At the end of this process, a total of 153 individual LPS registers from 13 official home matches were collected.

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Match types categorization

Consistent with previous studies (de Paula et al., 2020), we grouped (using k-means cluster analysis) the total number of matches (n = 182) played by all the teams in the entire competition (Spanish Women's 2nd Division) into different match types according to goal difference at the end of the match. Subsequently, we classified the 13 matches played by the team into three types of matches: 4 close matches (0-3 goals), 7 balanced matches (4-8 goals), and 2 unbalanced matches (>9 goals).

External load variables

Similar to previous research (Font et al., 2021; Font et al., 2023; García-Sánchez et al., 2024), the following external load variables (distance and accelerometry) were collected in absolute and relative values (normalized by playing time): (1) Total distance (TD); (2) High-speed running (HSR) corresponding to the distance covered above 18.1 km/h; (3) High-intensity braking distance (HIBD) corresponding to the distance covered with deceleration above 2 $m \cdot s^{-2}$; (4) Number of accelerations (ACC); (5) Number of decelerations (DEC); (6) PlayerLoad (PL).

Statistical analysis

Descriptive statistics are presented as means and standard deviations (M ± SD). Statistical significance level was set at $p<0.05$. The Kolmogorov-Smirnov test was performed to confirm data distribution normality and Levene's test for equality of variances. A two-way analysis of variance (ANOVA) followed by Tukey post-hoc was used to examine differences between playing positions and match types. Playing positions (i.e., backs, pivots and wings) and match types (i.e., closed, balanced and unbalanced) were set as independent variables. Furthermore, partial Eta-squared (ηp2) was calculated for group effects with the following interpretation: small (0.010–0.059), moderate (0.060–0.139), and large effect (>0.14) (Cohen, 1988). For the post-hoc analysis, Cohen's d (ES) was calculated and interpreted using Hopkins' categorization criteria, where 0.2, 0.6, 1.2 and >2 are considered small, moderate, large and very large effects, respectively (Hopkins et al., 2009). Data analysis was performed using SPSS for Windows (Version 26, IBM Corp., Armonk, NY, USA).

Results

Differences between match types

In relation to accelerometry variables, there were differences between types of matches with moderate effect size in DEC/min ($p<0.001$, $\eta p2 = 0.091$), but there were no differences in the rest of accelerometry variables ($p>0.05$) (Figure 1). More specifically, unbalanced matches (16.4±4.1 $n \cdot min^{-1}$) and balanced matches (15.2±3.8 $n \cdot min^{-1}$) elicited higher DEC/min than close matches (13.1±2.8 $n \cdot min^{-1}$) ($p<0.001$, ES = 0.88; $p<0.01$, ES = 0.55, respectively). Similarly, DEC values were higher during unbalanced matches (476.2±386.1) compared to balanced matches (457.8±275.5) and close matches (404.6±259.2), although not statistically significant. Furthermore, no significant differences were found in any distance variables ($p>0.05$).

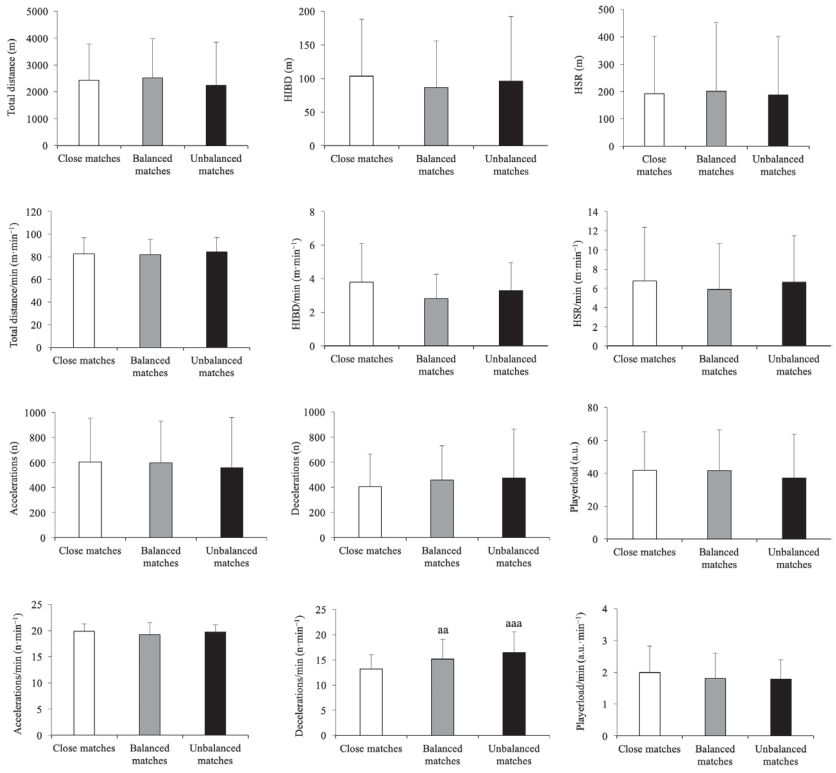

Figure 1. Influence of final score on external load variables. Significance level is indicated by the number of symbols: one symbol for $p < 0.05$, two for $p < 0.01$, and three for $p < 0.001$; [a] significant differences vs. close matches; [b] vs. balanced matches; [c] vs. unbalanced matches.

Differences between playing positions

In relation to distance variables, there were significant differences between playing positions with large effect size in TD ($p<0.001$, $\eta p^2 = 0.178$), HIBD ($p<0.001$, $\eta p2 = 0.350$), HSR ($p<0.001$, $\eta p2 = 0.502$), HSR/min ($p<0.001$, $\eta p^2 = 0.390$) (Figure 2). Wings covered largely more TD than pivots in balanced (3702.7±1656.3 m vs. 1667.3±1459.5 m) and unbalanced matches (3390.8±2128.1 m vs. 894.1±425.8

m) (p<0.001, ES = 1.54; p<0.05, ES = 1.90, respectively). Also, wings covered largely more TD than backs in balanced matches (p=0.002, ES = 1.11). Wings covered largely more HIBD than backs and pivots in close (+78.8 m, p=0.012, ES = 1.23; +133.1 m, p<0.001, ES = 2.08, respectively), balanced (+94.9 m, p<0.001, ES = 1.49; +132.4 m, p<0.001, ES = 2.08, respectively) and unbalanced matches (+124.3 m, p=0.003, ES = 1.95; +168.2 m, p<0.001, ES = 2.64, respectively). Additionally, wings covered largely more HSR than backs and pivots in close (+317.5 m, p=0.012, ES = 1.23; +367.1 m, p<0.001, ES = 2.08, respectively), balanced (+441.8 m, p<0.001, ES = 1.49; +482.8 m, p<0.001, ES = 2.08, respectively) and unbalanced matches (+352.8 m, p=0.003, ES = 1.95; +425.0 m, p<0.001, ES = 2.64, respectively).

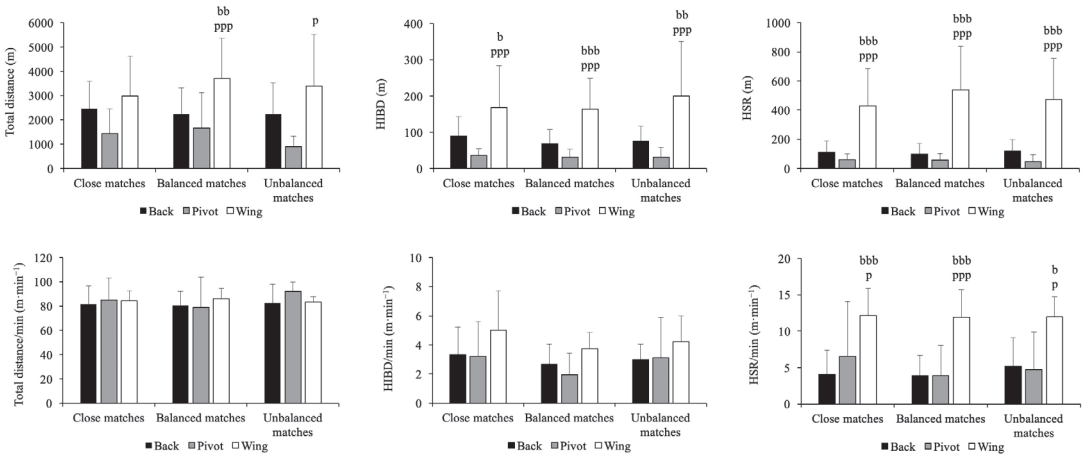

Figure 2. Influence of final score on distance variables of each playing position. Significance level is indicated by the number of symbols: one symbol for p < 0.05, two for p < 0.01, and three for p < 0.001; [b] significant differences vs. backs; [p] vs. pivots; [w] vs. wings.

In relation to accelerometry variables, there were significant differences between playing positions with moderate to large effect size in ACC (p<0.001, ηp2 = 0.130), DEC (p<0.001, ηp2 = 0.108), PL (p<0.001, ηp2 = 0.163) (Figure 3). Wings performed largely more number of ACC (775.5±467.3) and DEC (667.5±496.9) compared to pivots (190.0±95.1, p<0.05, ES = 1.76) (178.8±95.3, p<0.05, ES = 1.74) in unbalanced matches. Also, wings registered moderately more PL than backs and pivots in balanced and unbalanced matches (p<0.05, ES = 0.88-1.74). Furthermore, no significant interaction effect (playing positions vs. final score) was found in any external load variables (p>0.05).

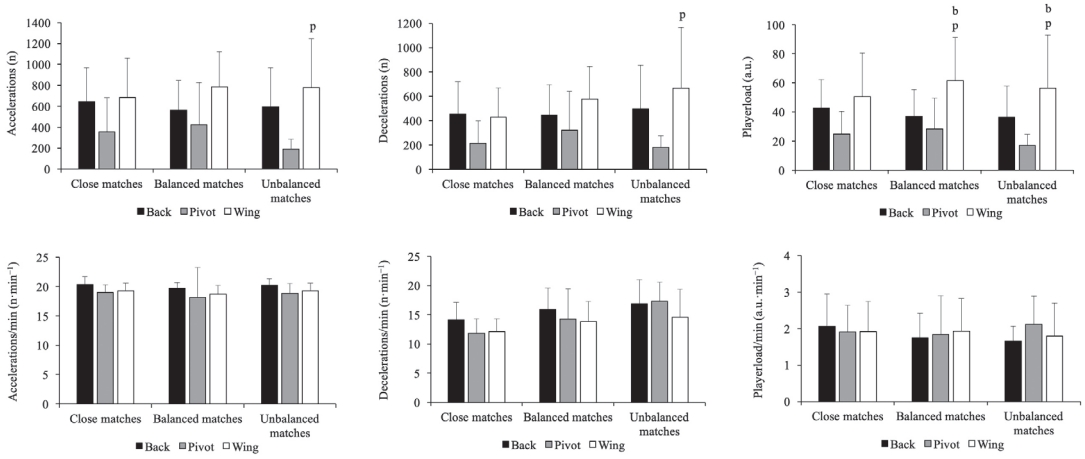

Figure 2. Influence of final score on accelerometry variables of each playing position. Significance level is indicated by the number of symbols: one symbol for p < 0.05, two for p < 0.01, and three for p < 0.001; [b] significant differences vs. backs; [p] vs. pivots; [w] vs. wings.

Discussion

To our knowledge, this is the first study to analyze and compare the influence of the final score on physical demands during official matches in women's handball. The main findings associated with match types indicated that: (1) unbalanced and balanced matches elicited higher values of DEC/min compared to close matches. Furthermore, the results connected to playing positions were the following: (1) wings covered largely more TD than pivots in balanced and unbalanced matches and more TD compared to backs in balanced matches; (2) wings covered largely more HIBD, HSR and HSR/min than backs and pivots regardless of the final score of the match; (3) wings performed largely more number of ACC and DEC compared to pivots in unbalanced matches; (4) wings registered moderately more PL than backs and pivots in balanced and unbalanced matches.

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In relation to match types, unbalanced and balanced matches elicited higher values of DEC/min compared to close matches. A possible explanation for these differences could reside in the combination of various characteristics of unbalanced matches: (1) a higher number of stolen balls and blocked throws (de Paula et al., 2020), (2) a higher game pace and a great number of ball possessions (Gómez et al., 2014), and (3) a higher number of quick transitions (counter-attacks) and quick goals (de Paula et al., 2020). Additionally, these results could also be related to some features of close matches: (1) a slower game pace, (2) a reduced number of ball possessions, and (3) a longer duration of attacks (Gómez et al., 2014). Consequently, if the number of counter-attacks increases in unbalanced matches, the players must tolerate a greater number of intense eccentric contractions during these matches, because each counter-attack action is followed by strong decelerations from a high velocity. This information suggests that players may experience high neuromuscular fatigue and tissue damage during unbalanced matches, especially if these high braking forces cannot be dissipated and distributed efficiently (Harper et al., 2019). Therefore, handball coaches and strength and conditioning specialists should incorporate different interventions (e.g., increase player substitutions) to mitigate the appearance of fatigue and tissue damage during matches with a large goal difference. Furthermore, handball coaches should employ small-sided games with different rules constraints (e.g., goal difference, number of players, duration and court dimensions) to best prepare players to cope the external load experienced during each match type (Corvino et al., 2014). This type of tasks could be an effective training tool to enhance aerobic and anaerobic capacities, as well as technical and tactical skills of the handball players (Buchheit et al., 2009).

Regarding playing positions, wings covered the largest TD and registered the highest values of PL in balanced and unbalanced matches. We hypothesized that these results could be related to their position on the court, because the handball playing area is longer in the outer aisles than the central domain of the court because of the design of the goal areas, enabling wings to cover larger distances (Póvoas et al., 2014). Additionally, wings covered largely more HIBD, HSR and HSR/min than backs and pivots regardless of the final score of the match. Recent research carried out with multi-directional team-sport athletes suggests that repeated high-intensity actions (associated with intense eccentric contractions) may produce fatigue, tissue damage, inflammatory responses, and impair neuromuscular performance (Markus et al., 2021; Harper et al., 2019; Harper et al., 2022). Likewise, wings performed largely more number of ACC and DEC compared to pivots in unbalanced matches. These results could also be related to the specific technical activity of each playing position. Previous studies indicate that wings usually perform more counter-attack actions than the other playing positions (Michalsik et al., 2015), so it seems reasonable to assume that if the number of counterattacks increases in unbalanced matches (de Paula et al., 2020) wings must tolerate more number of ACC and DEC. However, when these values were normalized according to the time the players spend on the court (n·min-1), backs performed moderately more ACC and DEC per minute than the other positions, although not statistically significant. Therefore, our results indicate that wings and backs players should incorporate different training interventions to mechanically protect players from these damaging consequences of high-intensity actions: (1) increase maximal and rapid force production with different strength training methods (e.g., eccentric and accentuated eccentric exercises, plyometric exercises, and weightlifting movements and their derivatives) to develop robust musculoskeletal structures (Harper et al., 2022); (2) increase the capacity of muscles and tendons with various training strategies (e.g., single- and double-leg landing stabilization exercises, pre-planned and unanticipated COD and rapid decelerations from a high velocity) to attenuate efficiently high braking eccentric forces (Harper et al., 2019); (3) improve aerobic-anaerobic capacity and repeated-sprint ability (Manchado et al., 2013; Póvoas et al., 2012). Nonetheless, despite the pivots performed lower total number of ACC and DEC compared to backs and wings, they should also be prepared to support the intensity of these actions during the competition. Consequently, coaches and practitioners should incorporate specific training interventions to properly prepare these players to cope the match demands.

Nevertheless, when interpreting the findings of this study, some notable limitations should be considered. First, external load was monitored only during thirteen official home matches. Accordingly, it should be noted that match location (away matches were not monitored) could have influenced our results. Second, the use of a very particular sample (i.e., a Spanish 2nd Division team) and not particularly large (n = 22), which does not represent the whole population. Third, LPS and IMUs may not reflect (tend to underestimate) the real physical demands of pivots, because these players usually perform some high-intensity actions (e.g., blocks and screenings) that not produce a displacement or acceleration. Fourth, our results did not differentiate specialist players (offensive or defensive). Fifth, the playing position of each player was established exclusively according to her position in attack, without taking into account her defensive position. Lastly, as it being an observational study, player rotations could not be controlled or influenced by researchers. Thus, coaches and practitioners should generalize and extrapolate these results with caution. In this regard, future research should include professional players (e.g., national teams or first-division clubs) and away matches.

In conclusion, the present study indicates that the final score of the match influences the physical demands experienced by semi-professional female handball players during official competitions. More specifically, our results revealed that unbalanced matches and balanced matches elicited higher DEC/min than close matches. In relation to playing positions, wings covered the largest TD and registered the highest values of PL in balanced and unbalanced matches. Also, wings presented the highest values of HIBD, HSR and HSR/min regardless of the final score of the match. Moreover, wings performed largely more number of ACC and DEC compared to pivots in unbalanced matches. Consequently, handball coaches and strength and conditioning specialists should consider the findings of the present study to adapt and periodize the training load across the microcycle. Also, they should take these results into account to make better strategical or tactical decisions during each match type (e.g. player substitutions) to mitigate fatigue and maintain physical performance throughout the match.

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