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Effective Playing Time in Women's Collegiate Volleyball

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ABSTRACT

Background: Limited research addresses variations in the effective playing time (EPT) across sets or matches, particularly within the collegiate female athlete population. Therefore, the purpose of this study was to examine the EPT and rally characteristics in women's collegiate volleyball among different sets.

Methods: Data were collected from 14 matches (49 sets, 2,094 points) played among six female university teams. Rally duration, rest intervals between rallies and sets, number of touches, rallies, and three-pass sequences were recorded. EPT and work-to-rest ratios were calculated. Rally length was categorised as short (<5 s), medium (5–10 s), or long (>10 s).

Results: The results showed that EPT was significantly greater ($p < 0.05$) in the third and fourth sets compared with the first and second sets. Rally duration, number of touches, and occurrence of three-pass sequences also demonstrated upward trends in later sets. Additionally, the proportion of short rallies was significantly lower in the first three sets compared with the fifth set.

Conclusion: These findings suggest that EPT tends to increase in the later sets compared to the initial sets, potentially reflecting increased match intensity as the game progresses. Recognising such patterns can help coaches and practitioners develop more targeted conditioning strategies to meet the physical demands of competition.

Keywords: Active playing time, performance analysis, team sports, work to rest ratio, number of touches

1. INTRODUCTION

Volleyball is widely recognised as one of the most physically demanding team sports which is played with two teams divided by a net in a specified court. It is unique among team sports because regulations force players to rotate through all six court positions, meaning every athlete must perform both offensive and defensive roles during a set (Laios & Kountouris, 2010). It also requires players to perform frequent, rapid, and context-specific motor actions – many of which occur without direct ball contact and are governed by time-limited, highly reactive conditions (Mroczek et al., 2014). Additionally, it is an intermittent team sport where high-intensity efforts alternate with pauses; in women's competitions, the mean action duration typically ranges from 7.03 to 8.72 seconds (Català et al., 2025), while in high-level play rallies most often lasts between 5 and 10 seconds, underscoring the explosive nature of the game and reinforcing the importance of analysing active playing time (Stanković et al., 2017). In 1998, the International Volleyball Federation (FIVB) changed some critical scoring, serving, and libero rules, which caused a reduction in the overall match length from approximately 96 minutes to 67 minutes in Spanish Volleyball League. In addition to that, a set ends at 25 points, which consists of 44 rallies on average. All of these modifications affect the temporal structure of the play and the effective playing time (EPT) values (Mroczek et al., 2014).

Despite these intense bursts of activity, the game also includes numerous rest periods, resulting in a substantial difference between total match duration and the actual time spent in active play. Consequently, the EPT, which is the duration that the players are actively engaged in play, often diverges significantly from total match length. In a volleyball match, rally durations differ, as well as the rest durations between rallies (Mroczek et al., 2014). Such variability in rally and rest times highlights the importance of considering EPT when analysing match demands (Sheppard et al., 2007; Wells, 2011). In volleyball matches, continuity has been described as the rational extension of active game actions, emerging through the tactical and technical interactions between teams across a sustained rally (Callejón & Hernández, 2009; Ureña et al., 2011, as cited in Valladares et al., 2016). From the EPT perspective, continuity is a key factor that enhances the meaningful duration of active play and reflects tactical richness.

Existing literature on volleyball has primarily focused on time–motion analysis, examining factors such as rally duration, rest periods, positional differences, and high-intensity movement patterns as jump frequencies, fatigue levels. For instance, Wells (2011) observed that rally duration averages around 7.6 seconds, followed by rest intervals of about 18.8 seconds, revealing that the ball is only in play for roughly 29% of the total match time, a substantial difference that emphasises the relevance of EPT in workload estimation. The work-to-rest ratio stood at about 1:2.50 (Wells, 2011). Similarly, Sheppard et al. (2007) reported rally durations between 3 and 40 seconds and average rest times near 14 seconds in national team players, highlighting consistent bursts of intense activity. These findings underscore the complexity of EPT and the inadequate representation of active playing time by traditional match statistics. Furthermore, although the rally-point system has elevated the strategic importance of the serve as an initial offensive weapon, empirical analyses reveal that serve error rates often surpass the efficiency ratios (García-Tormo et al., 2015; Quiroga et al., 2010, as cited in Valladares et al., 2016), and it complicates the contribution to EPT in terms of net rally continuation.

In spite of these studies having provided valuable insights into general match duration and activity patterns, there remains a significant gap in the literature. Limited research addresses variations in EPT across sets, particularly within the collegiate female athlete population. Additionally, fluctuations in EPT and their potential contribution to a player's fatigue remain largely unexplored. Monitoring the EPT should consider not only the temporal structure of play but also the physiological and perceptual fatigue accumulated during match participation (Ferreira da Silva et al., 2025). Valayi et al. (2024) also demonstrated that performance fatigue adversely affects visual perception, concentration, and reaction time among professional female volleyball players, indicating that fatigue extends beyond mere physical decline to cognitive components crucial in match performance. Research on women's team sports has shown that post-match fatigue responses such as cortisol, creatine kinase, and muscle soreness can persist up to 72 hours, underscoring the cumulative stress imposed by high-effort rallies and active playing time (Ferreira da Silva et al., 2025). Proper statistical analysis of game actions is essential for identifying the most decisive elements of women's volleyball and for guiding effective training strategies (Valladares et al., 2016). This gap in the literature suggests the need for a deeper understanding of EPT's contribution to physical strain and its potential to inform targeted training interventions.

To address these research gaps, this study aimed to explore variations in EPT and rally characteristics throughout different sets in women's collegiate volleyball. For the rigorous schedules in women's collegiate volleyball, understanding EPT dynamics may offer valuable insights for coaching and conditioning staff. A secondary objective was to investigate the differences in ball-contact patterns further enriching the understanding of match demands and performance determinants.

2. METHODS

Match sample

A total of 14 matches, 49 sets, and 2,094 points played between six female university volleyball teams participating in the UniLeague Play-Off tournaments were collected. All team players were university students over the age of 18. Prior to data collection, approval from the Turkish University Sports Federation was taken, and written informed consent was obtained from each team's head coach on behalf of their players. Ethical approval for this study was obtained from the Human Subjects Ethics Committee of Middle East Technical University (0162-ODTUIAEK-2025), ensuring that the research adhered to ethical guidelines for human-based observational research. In this study, individual players were not directly involved in time-based data and match events were observed from recorded footage. Matches were played to the best of five sets.

Instruments

The UniLeague Play-Off tournaments are played in an indoor sports hall with an official volleyball (*Mikasa V200W*). All matches were recorded using a professional digital video camera (*Sony HXR-NX200, Japan*) with a frame rate of 60 frames per second and a resolution of 1080p. This allowed for precise time analysis without frame loss or distortion during fast-paced rallies. Adobe Premiere Pro was employed to watch and analyse the match videos. Microsoft Excel 365 was used to calculate the durations. Two independent observers watched the videos and the data collected.

Procedure

Data was collected over five tournament days during the UniLeague Play-Off phase. Matches started each day at 10:00 AM and were completed by 4:00 PM at the earliest. Until the last day of the tournament, a total of three matches were played per day; however, on the last day one of the teams did not show-up, resulting in 14 matches in total. Throughout the matches, video recordings were conducted continuously without any pauses or interruptions, ensuring accurate calculation of EPT by eliminating potential human error.

In volleyball, rallies begin with the first touch of the server and end when the ball touches the ground. In a volleyball match, a serve is the action that initiates play, executed by striking the ball from behind the end line to send it over the net into the opponent's court, thereby starting each point (Rebelo et al., 2025). Since every rally necessarily begins with a serve, these actions were not included in the calculation of the number of touches in the present study. The inclusion of block touches in the analysis was determined based on their influence on the rally outcome. A block is a defensive manoeuvre at the net, executed with the hands and arms to intercept or redirect an opponent's attack, aiming to stop the ball from crossing into one's court (Rebelo et al., 2025). However, blocks do not always alter the flow of play in the same way as ball contacts that sustain rallies. Thus, if the ball was kept in the play, block touches were not included in the calculation of the number of touches. However, if it directly affects the point, it is included in the touch counts. The EPT was determined by analysing the total duration of the rallies as the ball was actively in play, excluding interruptions, time-outs, and breaks between rallies and sets. It was calculated by dividing the total rally time by the total set for calculating the EPT of the set and by the total match time for the EPT of the match, then multiplying the result by 100 to express it as a percentage. The work-to-rest ratio was calculated by dividing the rest time by the rally length. After the matches were recorded, observers were instructed to identify and time-stamp key match events based on a standardised coding protocol. Inter-observer reliability was ensured by comparing and cross-checking the coded time data. Discrepancies were discussed and resolved through consensus, and in cases of significant variation, the event in question was re-analysed jointly. To establish the consistency and accuracy of the data collected, this method ensured high internal consistency, reduced human error, and enabled robust performance metrics to be extracted from the match footage.

Statistical analysis

The descriptive statistics (means and standard deviations) were calculated for all study variables. The Shapiro–Wilk test was conducted to check normality. Since the assumption of normality was violated, the Kruskal–Wallis test was used to compare variables across different sets. The Mann–Whitney U test was used for follow-up pair-wise comparison between sets. The significance level was set at $p < 0.05$ for all statistical tests. The IBM SPSS (v.26.0) for Windows was utilised to analyse data.

3. RESULTS

The results of the study showed that there were 9 three-sets, 3 four-sets, and 2 five-sets matches played. The mean match durations for three-, four-, five-set matches were 82.32 ± 11.48 minutes, 116.44 ± 2.14 minutes, and 138.46 ± 0.03 minutes, respectively. The overall average duration across all matches was 97.54 ± 24.15 minutes.

The descriptive statistics on rally duration, set duration, rest between rallies, rest between sets and time-outs across different sets are presented in Table 1. The Kruskal–Wallis test results revealed that there was a statistically significant difference in number of touches ($\chi 2$ (4) = 12.651, p = 0.013), number of three passes ($\chi 2$ (4) = 15.664, p = 0.004), and rally duration ($\chi 2$ (4) = 13.514, p = 0.009) between the sets. The Mann–Whitney U test results showed significant differences between Set 1 and 5 (U = 11,897.5, p = 0.034), Set 2 and Set 3 (U = 173,243.5, p = 0.023), Set 2 and 4 (U = 63,616.5, p = 0.017), and Set 2 and Set 5 (U = 12,170.0, p = 0.016) in number of touches. There were significant differences between Set 1 and Set 4 (U = 61,308.5, p = 0.033), Set 1 and Set 5 (U = 11,929.0, p = 0.031), Set 2 and Set 3 (U = 171,293.0, p = 0.008), Set 2 and Set 4 (U = 62,718.5, p = 0.006), and Set 2 and Set 5 (U = 12,192.5, p = 0.014) in number of three passes. The results also indicated significant differences between Set 1 and Set 3 (U = 165,992.5, p = 0.045), set 2 and Set 3 (U = 170,178.5, p = 0.006), and Set 2 and Set 4 (U = 63,359.5, p = 0.014) in rally duration.

Table 1. **Descriptive statistics of mean point and set durations and number of touches, rallies, and three passes across sets**

Variables / Sets	**1**	**2**	**3**	**4**	**5**	**Total**
Rally duration (sec)	7.48 (±7.12)	7.37 (±7.12)	8.35 (±7.53)	9.20 (±8.46)	9.22 (±7.43)	8.10 (±7.37)
Rests between rallies (sec)	29.49 (±3.17)	30.28 (±3.55)	27.35 (±4.50)	26.28 (±1.35)	31.20 (±0.32)	29.03 (±1.83)
Set duration (min)	28.05 (±4.24)	29.39 (±4.40)	27.00 (±5.51)	28.38 (±2.12)	17.51 (±0.17)	–
No of touches (#)	5.41 (±5.69)	5.35 (±5.98)	5.93 (±6.04)	6.61 (±6.94)	6.90 (±6.04)	5.70 (±6.04)
No of rallies (#)	1.84 (±2.23)	1.84 (±2.34)	2.00 (±2.36)	2.22 (±2.58)	2.33 (±2.19)	1.94 (±2.34)
No of 3 passes (#)	1.48 (±1.69)	1.45 (±1.77)	1.64 (±1.80)	1.88 (±2.09)	1.98 (±1.92)	1.57 (±1.80)

The EPT and work to rest ratio across different sets are illustrated in Figures 1 and 2. The results demonstrated that the average EPT and work to rest ratio is 21.58 (± 2.24) and 1:3.63 (± 0.49) respectively. The Kruskal–Wallis test results indicated that there were statistically significant differences in EPT ($\chi 2$ (4) = 18.556, p < 0.001) and work to rest ratio ($\chi 2$ (4) = 11.269, p = 0.024) between sets. The Mann–Whitney U test results showed significant differences between Set 1 and Set 3 (U = 40.0, p = 0.008, effect size (ES) = 0.50), Set 1 and Set 4 (U = 2.0, p = 0.002, ES = 0.70), Set 2 and Set 3 (U = 37.0, p = 0.005, ES = 0.53), and Set 2 and Set 4 (U = 0.0, p = 0.001, ES = 0.74) in EPT. There were significant differences between Set 1 and Set 4 (U = 7.0, p = 0.010, ES = 0.59), Set 2 and Set 3 (U = 54.0, p = 0.043, ES = 0.38), and set 2 and Set 4 (U = 6.0, p = 0.007, ES = 0.62) in work to rest ratio.

Figure 1. **Effective playing time (%) across different sets**

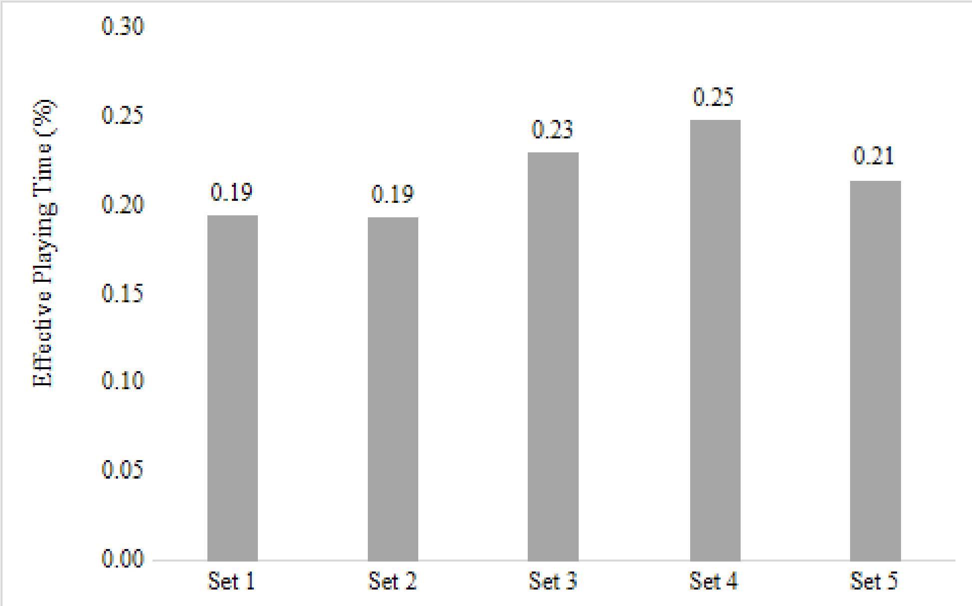
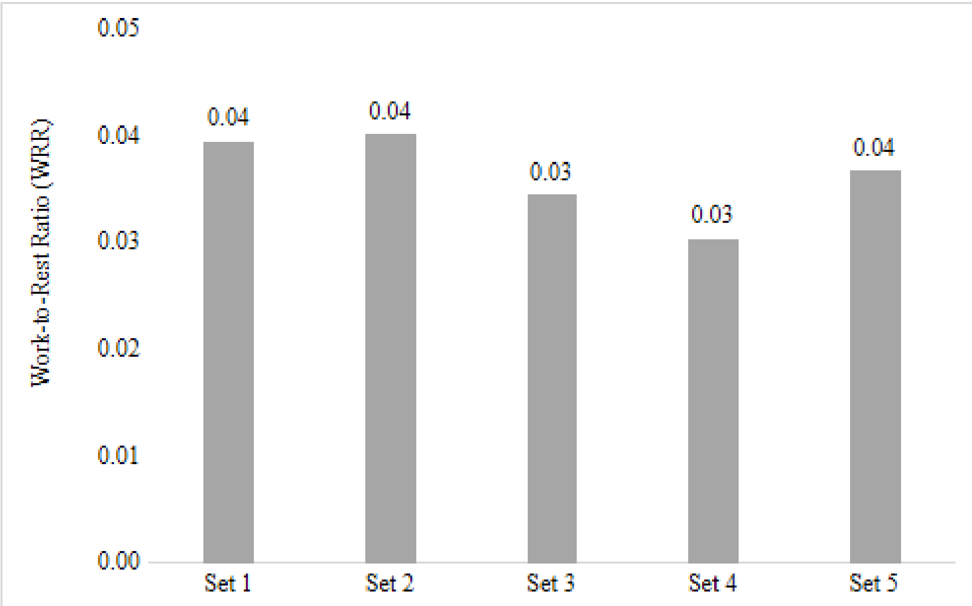


Figure 2. **Work to rest ratio across different sets**



The distribution of short, middle, and long rally lengths is represented in Table 2. The results indicated that the percentages of short, middle, and long rallies are % 49.09, % 26.36, and 24.55 respectively. The Kruskal–Wallis test results revealed that there was a statistically significant difference in short rallies ($\chi2$ (4) = 14.362, p = 0.006) between the sets. The Mann–Whitney U test results showed significant differences between Set 1 and 5 (U = 0.0, p = 0.025), Set 2 and 3 (U = 36.500, p = 0.005), Set 2 and 5 (U = 0.0, p = 0.025), and Set 3 and 5 (U = 0.0, p = 0.025).

Table 2. **Distribution of rally lengths across sets**

Sets	Short Rallies (1–5 Second)	Medium Rallies (6–10 Second)	Long Rallies (>10 Second)
1st set (%)	50.93	25.63	23.44
2nd set (%)	53.37	25.32	21.31
3rd set (%)	45.17	28.67	26.17
4th set (%)	45.61	24.12	30.26
5th set (%)	36.73	30.61	32.65
Total (%)	49.09	26.36	24.55

4. DISCUSSION

The present study aimed to analyse EPT across sets in collegiate women's volleyball. The main finding was that EPT fluctuated across sets, with a tendency for increased values in later stages of matches. This observation complements previous literature emphasising the critical role of rally duration and rest intervals in shaping volleyball performance (Stanković et al., 2017). Performance in elite women's volleyball is often determined by subtle technical and tactical details such as serve and reception quality (Valladares et al., 2016). In line with this, our results indicate that as match duration increases, rally length and recovery time become more variable, potentially influencing player workload. Prior research confirms that fatigue has multidimensional effects – ranging from visual perception and reaction time (Valayi et al., 2024) to anticipation skills and explosive actions like jumping and spiking (Yu et al., 2025). These findings are consistent with Cabarkapa et al. (2024), who reported strong correlations between perceived exertion and external load indicators, underscoring that intensity and cumulative fatigue are key contributors to decreased performance. Thus, fluctuations in EPT throughout a match may reflect both physiological and psychomotor fatigue mechanisms.

Another research has highlighted that rest time, rather than rally duration, is the primary determinant of match dynamics (Aytar et al., 2019), raising questions about whether EPT reductions can be attributed solely to fatigue. These patterns strengthen the case for monitoring EPT as a practical workload indicator. However, not all studies fully align with our results; for instance, Wells (2011) reported relatively stable work-to-rest ratios across sets in women collegiate samples. This contrast may be explained by differences in competition level, match density, or methodological approaches to quantifying effective playing time.

Stanković et al. (2017) reported a work-to-rest ratio of approximately 1:1.86 in competitive male volleyball players, indicating that players spent nearly twice as much time recovering as actively playing. In contrast, the present study revealed a considerably higher ratio as 1:3.63, suggesting that athletes in our sample devoted proportionally more time to rest. One possible explanation for this discrepancy lies in rule changes: for example, the European Volleyball Confederation (CEV) abolished technical time-outs in 2018 to increase the continuity of play (World of Volley, 2018). Nevertheless, even without these mandatory breaks, our sample exhibited longer relative rest periods. A potential reason may be that, at elite levels, the incidence of simple errors such as service faults is considerably lower. When rallies begin with a serve lasting only a few seconds but are surrounded by relatively long pre- and post-rally pauses, the overall EPT decreases and the calculated work-to-rest ratio increases. Thus, the higher ratio observed in our study may reflect both structural rule modifications and performance characteristics specific to this competition level.

The present study has several limitations. First, the relatively small sample size (14 matches) restricts the generalisability of the findings to broader populations. Second, the cross-sectional observational design prevents causal inferences about EPT fluctuations. Third, the absence of physiological markers (e.g. heart rate, biochemical variables) limits the ability to directly explain the physiological mechanisms underlying changes in EPT. Further studies should replicate these findings in larger samples and across different competitive levels, including professional and youth populations. Longitudinal research combining time–motion analysis with physiological and perceptual fatigue measures is needed to better clarify the causal links between EPT and performance decline. Future work could also examine how evolving rules, rally-point scoring systems, or tactical strategies may further shape EPT responses.

Practical applications

The ultimate aim of coaches and conditioning staff is to enhance competitive performance, which requires careful management of training intensity, load, and recovery. Monitoring EPT offers a practical framework to support this process. Conditioning drills can be designed to replicate the average work-to-rest ratios observed in competition, while recovery protocols should take into account the cumulative fatigue reflected in decreasing EPT across sets. Training sessions should also be structured to incorporate competition-specific intensity, ensuring athletes reach their optimal performance levels during matches (Sánchez-Moreno et al., 2016). By integrating EPT analysis into daily practice, coaches can not only optimise load management but also make more informed decisions about substitutions and tactical adjustments during play. Despite its significance, EPT has often been overlooked in traditional match statistics, yet it directly influences physical load, fatigue accumulation, and recovery demands, making it an essential parameter for practical performance optimisation.

5. CONCLUSIONS

In summary, this study demonstrated that EPT varies across sets in collegiate women's volleyball. These results highlight the importance of EPT as both a monitoring tool and a practical guide for conditioning and recovery planning in women's volleyball. Beyond its descriptive value, EPT provides actionable insights into how players experience workload during matches, offering coaches an evidence-based parameter for tailoring training loads, managing recovery, and reducing injury risk. By identifying fluctuations in EPT across sets, practitioners can design more competition-specific drills, optimise substitution strategies, and implement recovery interventions that better match the physiological and psychomotor demands of the sport. Collectively, these findings underscore that integrating EPT into routine performance analysis is essential for advancing both scientific understanding and practical performance optimisation in women's volleyball.

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Declaration of Generative Artificial Intelligence (GenAI) Use: During the preparation of this work the authors used ChatGPT to enhance readability and writing quality of this manuscript (OpenAI, 2026). After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

No artificial intelligence tools were used to review or summarise the literature, assess the statistical analyses, interpret the findings. Human oversight and supervision were maintained throughout all phases of the study.

Conflicts of Interest: The authors declare no conflict of interest.

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