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Stankovi, Mladen; Peri, Dušan; Ruiz-Llamas, Guillermo; Quiroga-Escudero, Miriam E.

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Effects of Tested Rules on Work-Rest Time in Volleyball

Mladen Stanković^{1*}, Dušan Perić², Guillermo Ruiz-Llamas¹, Miriam E. Quiroga-Escudero¹

ARTIGO ORIGINAL | ORIGINAL ARTICLE

ABSTRACT

The aim of this study was to determine the influence of new rules tested at the inaugural Men's Under 23 (U23) World Championship (set to 21 points and 15 seconds between the end of a point and the new serve) on all aspects of time in volleyball matches. The study sample comprised 36 matches partially segmented into 123 sets and 4583 points played. Applying one-way ANOVA, it was shown that the active part of the set and the whole match last slightly more than one third of the total time. The most frequent rally duration was 5 to 10 seconds (43.5% of points). As sets became more unpredictable and approached the end, rest time between points was longer. Time analysis of volleyball matches is important as it helps with proper development of physical preparation for players, gives coaches insight into appropriate match flow and provides a clear time frame of each part of a volleyball match for organisers of competitive events, pools, championships and tournaments.

Keywords: elite male volleyball, match duration, set phases, rally duration, time

INTRODUCTION

The sport of volleyball has no time limits on the length of official matches. The first team to win 3 sets is the match winner (Fédération Internationale de Volleyball [FIVB], 2012). The duration of a volleyball match has changed over time. The length of a match obviously depends on its parts: scoring system, rally length (work time of the game), rest time (time between rallies, substitutions, sanctions, technical and team time-outs, time between sets, injuries, and other technical aspects) and level of the players (Häyrinen et al., 2011). The rally is the basic unit of one point, the time when a team can score a point. It is differentiated from the other parts of the game, which are considered rest time (Fellingham, Collings, & McGown, 1994).

Changes to the scoring system in beach volleyball introduced by Fédération Internationale de Volleyball (FIVB) and Association of Volleyball Professionals (AVP) to satisfy TV broadcasting needs was a major factor in the growth of this sport (Giatsis, 2003). At the inaugural FIVB U23 Men's World Championship, held in Brazil in October 2013, new rules were tested with the idea of modernising volleyball and

making it more appealing for fans both at matches and watching television (FIVB, 2013a). Obviously, the main way to change match duration is to modify the scoring system, and this has been done several times (Ureña, Gallardo, Delgado, Hernández, & Calvo, 2000) during the history of volleyball. Studies of beach volleyball and volleyball found that match duration changed significantly after changes to the scoring system (Giatsis, 2003; Kountouris & Laios, 2000).

The changes tested (set to 21 points, excluding the fifth set to 15 points, with two points minimum difference at the end of sets; server has 15 seconds after the finished point to perform serve - 10 seconds to prepare and 5 seconds to execute the serve) were the first officially tested modifications of the Rally Point System (FIVB, 2013a; FIVB, 2015).

The results can provide an understanding of the effect of the rule changes and help to identify the best way to prepare volleyball teams physically, mentally and tactically, not only at the highest level, but also in the various stages of youth development. At the same time, this study can help the FIVB to make volleyball more attractive for audiences and television companies,

¹ Universidad de Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain

² Faculty of Sport and Tourism, Novi Sad, Serbia

* E-mail: mladen_stankovic@yahoo.com

and contribute to the development of volleyball in general.

The purpose of this study was to determine the detailed effects of the tested rules (set to 21 points and 15 seconds maximum to next serve after finished point) on time in volleyball matches.

METHOD

Participants

The analysis comprised 36 hours from 36 matches of the 38 games played at the U23 Men's World Championships in Uberlandia (Brazil). For the first time, a world championship was organised for under 23 male players, and competition took place in October 2013, with 12 national teams (144 players) participating. The FIVB organised the tournament following the competition system, testing two new rules: set to 21 points (excluding the fifth set, to 15 points) with a two-point minimum difference at the end of sets, and 15 seconds for the server to execute the serve after the finished point (FIVB, 2013b).

FIVB officially authorised the use of all videos of matches and data from the Volleyball Information System (VIS) and the FIVB website. This study was performed in accordance with the Helsinki Declaration of 1975.

Measures

Competition structure

Competition had two rounds: group phase (Pool A and B), and semi-finals and finals. In the group phase 30 matches were played and in the semi-finals and finals 8 matches were played. The 12 teams, divided into 2 groups of 6, played according to the round-robin system to determine the ranking and were classified from 1st to 6th. The team ranked 3rd in Pool A played the team ranked 4th in Pool B. The team ranked 3rd in Pool B played the team ranked 4th in Pool A. The losers of these semi-final matches played for 7th and 8th final places and the winners played for 5th and 6th places. The team ranked 1st in Pool A played the team ranked 2nd in Pool B. The team ranked 1st in Pool B played the team ranked 2nd in Pool A. The losers of the semi-final matches played for 3rd and 4th place and the winners played for 1st and 2nd place (FIVB, 2013c).

Variables

Palao, Valadés, and Ortega (2012) studied the variables of match duration, total rallies per set and match, number of sets, team that won the set and the match, and type of match, established through the point difference between teams and gender. Häyrynen et al. (2011) analysed the duration of rallies, sets (no 5th sets), and breaks between rallies (no time-outs or breaks between sets). Vilamitjana et al. (2008) studied the time variables of work time during the set: total set time minus rest time (time-outs, player substitution time and time for the ball to reach the serve). They also analysed total jumps and total work time per subject.

In this study, all parts of the match duration were used as variables:

1. Work time (time between the referee's whistle for serve and the end of the point).
2. Rest time:
 - A. Time after the whistle for finished point until the whistle for serve.
 - B. Team time-out:
 - a) Time before the whistle for the beginning of team time-out.
 - b) Time between two whistles (time-out).
 - c) Time after the whistle for the end of team time-out.
 - C. Technical time-out:
 - a) Time before the whistle for the beginning of technical time-out.
 - b) Time between whistles.
 - c) Time after the whistle for the end of technical time-out.
 - D. Player substitutions:
 - a) Time before the whistle for substitution.
 - b) Time between whistles.
 - c) Time after the whistle for the end of substitution.
 - E. Player sanctions:
 - a) Time before the whistle for sanction.
 - b) Time between whistles.
 - c) Time after the whistle for the end of sanction.
 - F. Time between sets (time after the whistle for the end of last point until whistle for new set).

- G. Player injury time.
- H. Time of other technical aspects (fixing fallen antenna, problem with referee's chair):
 - a) Time before the whistle for fixing the technical problem.
 - b) Time between whistles.
 - c) Time after the whistle for the end of the technical problem.

FIVB technicians specially trained to use the VIS, who were approved, supervised and appointed by the FIVB Technical Commission, collected the data. VIS software processes all data collected and is one of the two methods most commonly used by coaches and observers to assess individual and collective performance of volleyball players in each phase of the match. The variables were assessed by methodical observation of every second of the games. To ensure reliability of the observation, a single observer with experience in volleyball scouting and good knowledge of volleyball observed all matches. The intraobserver Cohen's Kappa values obtained in observation of all the variables were higher than 0.81, the minimum value to be considered almost perfect agreement (Landis & Koch, 1977). To ensure the time reliability of the measurement, the same procedure was performed twice, in an interval of 10 days, and Cohen's Kappa values higher than 0.81 were obtained.

Procedures

Part of the data was collected by watching all matches and the remaining data were taken from the VIS, on the FIVB website. All data were recorded on an analysis scheme form, used to define and examine the variables (Tsimpiris, Tsamourtzis, Sfingos, Zaggelidis, & Zaggelidis, 2006). The FIVB authorised official collection of match videos and data from the VIS and the FIVB website. All matches were filmed using a PANASONIC HC-V720HD digital camcorder in AVCHD format. The camera was always located behind the court at a height of 5 m above the floor (Claver, Jiménez, Gil, Moreno, & Moreno, 2013) to give the best angle to follow everything happening on and beside the court.

VIS software has been used in various studies (Marcelino & Mesquita, 2008; Marcelino, Mesquita, & Afonso, 2008; Marcelino, Mesquita, Palao, & Sampaio, 2009). Its purpose is to quantify individual skills and it is accepted as a valid instrument in volleyball research.

Statistical analysis

IBM SPSS Statistics V19 software was used for the statistical analysis. All data were primarily processed by descriptive statistic procedures for each variable. One-way ANOVA was applied to test the significance of differences between the arithmetical means at different phases of the set and in sets with different levels of win. For more in-depth analysis and because of a small number of unbalanced observations in different categories of "time between sets", the Kruskal-Wallis nonparametric test was used. All tests were performed at the level of significance of 0.05 ($p < 0.05$).

RESULTS

After measuring each part of total match duration, it was determined that total work time (time when the ball is in play) is a significantly smaller part than rest time, which has many components. Work time of the match and the set last slightly more than one third of the total time (Figures 1 and 2).

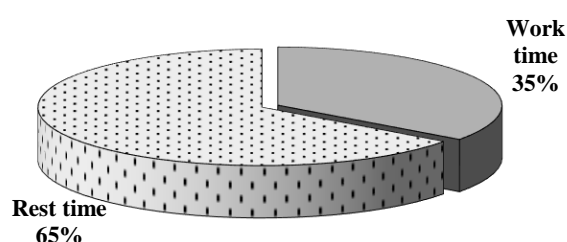


Figure 1. Relation of total work and rest time during a volleyball match.

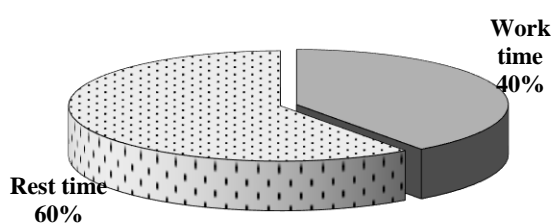


Figure 2. Relation of total work and rest time during an average set.

The longest element of rest time during a volleyball match corresponds to periods between rallies (27.37% of total match duration) and both

time-outs (19.12%), followed by pauses between sets (12.04%) and substitutions (6.05%) (Table 1).

Table 1

Mean duration of each part of the match

Variable	N	Mean (s)	Std. Dev. (s)	Std. Error (s)	Min. (s)	Max. (s)	Share of Set (%)	Share of Match (%)
Point duration	4588	11.50	4.38	.065	2.84	41.50	39.78	34.99
Time after point	3568	11.57	2.08	.035	3.17	47.17	31.12	27.37
Time-out							14.82	13.03
Before the whistle	313	8.04	3.77	.213	.17	35.50	1.90	1.67
Between whistles	326	35.68	5.45	.302	24.33	64.33	8.77	7.71
Time after the whistle	325	16.92	5.46	.303	1.84	53.00	4.15	3.65
Technical time-out							6.92	6.09
Before the whistle	119	3.75	2.08	.190	.84	13.50	.34	.30
Between whistles	119	59.73	4.02	.368	53.33	76.17	5.36	4.71
Time after the whistle	119	13.63	4.89	.449	.00	26.17	1.22	1.08
Substitution							6.88	6.05
Before the whistle	413	6.61	3.09	.152	1.00	24.17	2.06	1.81
Between whistles	473	10.27	4.72	.217	2.67	60.17	3.66	3.22
Time after the whistle	409	3.77	3.01	.149	.84	21.00	1.16	1.02
Time between sets	87	208.81	27.66	2.966	143.84	399.33	/	12.04
Sanction							.31	.27
Before the whistle	10	14.47	4.69	1.484	8.33	21.00	.11	.10
Between whistles	10	21.49	8.43	2.664	9.00	38.33	.16	.14
Time after the whistle	10	4.92	3.93	1.242	2.17	12.33	.04	.03
Side change in 5th set	4	54.45	2.56	1.281	52.23	56.67	.16	.14
Other technical aspects							.03	.02
Before the whistle	1	8.50	/	/	8.50	8.50	.01	.01
Between whistles	1	20.00	/	/	20.00	20.00	.02	.01
Time after the whistle	1	2.50	/	/	2.50	2.50	.00	.00
Set duration	123	1226.38	312.85	8.861	1132.76	1420.83	100	/
Match duration	36	4190.08	1135.74	37.443	3398.27	6820.50	/	100

Note. S = seconds. In the following tables all descriptive parameters (Mean, Std. Deviation, Std. Error, Min, and Max) are shown in seconds (s).

Mean set duration was 1226.38 ± 312.85 seconds (20.44 ± 5.21 minutes), with the longest set lasting 1420.83 seconds (23.68 minutes) and the shortest lasting 1132.76 seconds (18.89 minutes). Mean match duration was 4190.08 ± 1135.74 seconds (69.83 ± 18.93 minutes), with the longest and shortest matches lasting 6820.50 seconds (113.68 minutes) and 3398.27 seconds (56.64 minutes), respectively.

It is significant that the highest number of pauses between finished points and the referee's whistle for serve lasted more than 10 seconds in most cases (about 12 seconds) (Figure 3). The rules tested at the Championship attempted to control this aspect. Even though some pause periods lasted more than 20 seconds, the number of long pauses was kept to a reasonable level.

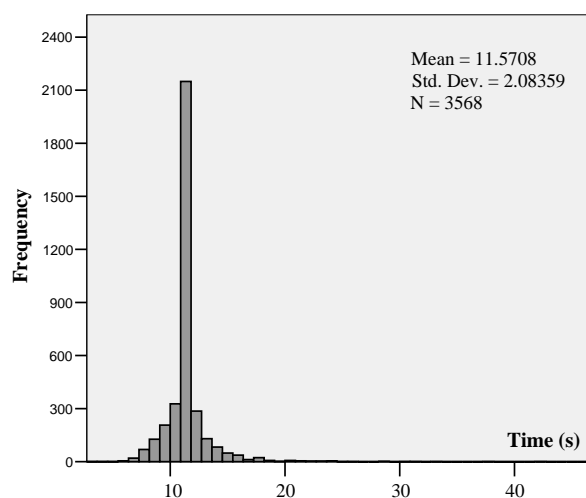


Figure 3. Distribution of pauses after rallies by duration.

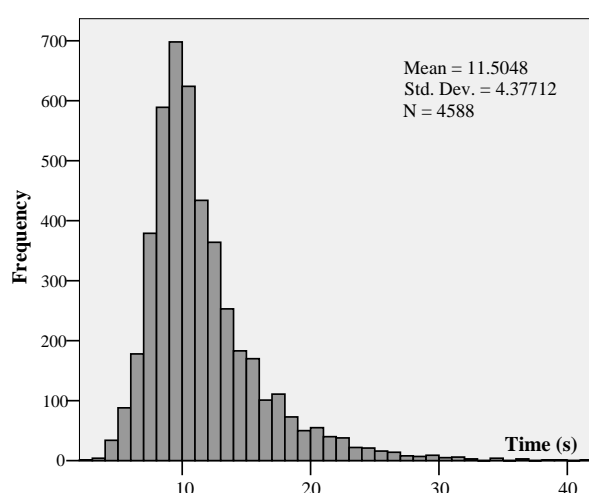


Figure 4. Distribution of finished points by duration.

The duration of the points finished during the matches analysed is worth noting. The most frequent point duration was 5 to 10 seconds (43.5%) (Figure 4), followed by 41% of points lasting 10-15 seconds. About 11% of the points finished during the match lasted 15-20 seconds and 3.7% lasted 20-25 seconds.

Total team time-out lasted 13.03% of the match duration, more than twice the value for technical time-out (6.09% of match duration).

Total team time-out, comprising time before the whistle for the beginning of time-out, time between whistles (time-out) and time after the

whistle for the end of time-out until the next referee's signal (e.g., for serve or substitution), had a mean duration of 60.64 seconds. Total technical time-out had a mean duration of 77.11 seconds. Approximately 17 seconds lapsed from the end of team time-out until the new signal from the referee (e.g., for serve). The mean time spent during the period before the signal for the beginning of time-out was 8 seconds for team time-out and approximately 4 seconds for technical time-out.

For this study it was interesting to compare rally duration and rest time between rallies at different phases of the sets. The starting assumption was that the trend of the results would influence tactical acceleration or prolonging of the game. Variance analysis (Table 2) showed no significant difference between the mean duration of an active game in relation to *Early*, *Middle* and *Final phase* of the sets, although a significant difference was found between the mean duration of pauses or rest time after rallies and *Early*, *Middle* and *Final phase* of the sets (Table 3). Post hoc analysis showed that the source of variability was prolonging the pause in the *Final phase* of the sets. Rest time between points was almost the same in *Early* and *Middle phase* of the sets, with a value of 11.47 seconds.

Table 2

Rally duration in different phases of the set

Phase of the set	N	Mean (s)	Std. Dev. (s)	Std. Error (s)	Min. (s)	Max. (s)
Early phase	1723	11.69	4.55	.109	3.67	38.00
Middle phase	1563	11.33	4.21	.106	2.84	41.50
Final phase	1302	11.46	4.33	.120	3.84	36.84
Total	4588	11.50	4.38	.065	2.84	41.50

F=2.855; $p = .058$

Table 3

Duration of rest time after the rally in different phases of the set

Phase of the set	N	Mean (s)	Std. Dev. (s)	Std. Error (s)	Min. (s)	Max. (s)
Early phase	1721	11.46	1.28	.03088	3.17	31.00
Middle phase	1561	11.47	1.87	.04745	5.17	41.84
Final phase	1299	11.81	2.34	.06493	6.17	47.17
Total	4581	11.57	1.84	.02717	3.17	47.17

F=10.661*; $p = .000$

One-way ANOVA was used to compare the mean point duration and mean pause duration in sets of different *Win Level* (*Walkover*, *Balanced*, and *Tough set*). Once again, a significant difference

was found only for rest time after points (Tables 4 and 5). As sets became more unpredictable, rest time between points was longer.

Table 4

Rally duration in sets of varying win level

Phase of the set	N	Mean (s)	Std. Dev. (s)	Std. Error (s)	Min. (s)	Max. (s)
Walkover	1889	11.48	4.22	.097	3.84	36.84
Balanced	1414	11.43	4.43	.118	2.84	41.50
Tough	1285	11.63	4.54	.127	3.33	38.00
Total	4588	11.50	4.38	.065	2.84	41.50

F=.791; $p = .453$

Table 5

Duration of rest time after the point in sets of varying win level

Phase of the set	N	Mean (s)	Std. Dev. (s)	Std. Error (s)	Min. (s)	Max. (s)
Walkover	1882	11.31	1.41	.033	3.67	30.17
Balanced	1414	11.43	1.87	.050	3.17	41.84
Tough	1285	12.05	2.25	.063	6.67	47.17
Total	4581	11.57	1.84	.027	3.17	47.17

F=43.585*; $p = .000$

Total substitution time accounted for 6.05% of match duration and 6.88% of set time. The mean duration of substitutions was 10.27 ± 4.72 seconds and the maximum value for a single substitution was 60.17 seconds. The mean time for calling substitutions was 6.61 ± 3.09 seconds. Time between sets accounted for 12.04% of match duration and the mean value was 208.81 ± 27.66 seconds (3.48 ± 0.46 minutes). The longest period between sets was 399.33 seconds

(6.66 minutes) and the shortest period between sets was 143.84 seconds (2.40 minutes). A more in-depth analysis of time between sets revealed no significant differences (Table 6).

The shortest parts of sets and matches were sanctions, accounting for 0.31% of time in sets and 0.27% in matches, followed by the side change in the fifth set and other technical aspects (fixing a fallen antenna, fixing a problem with the referee's chair...). No time was spent on injuries.

Table 6

Duration of pauses after each set in numerical order

Time between sets	N	Mean (s)	Std. Dev. (s)	Std. Error (s)	Min. (s)	Max. (s)
After 1 st set	36	204.83	16.42	2.737	153.67	235.67
After 2 nd set	36	210.77	38.02	6.337	143.84	399.33
After 3 rd set	11	207.12	14.36	4.328	171.50	225.17
After 4 th set	4	231.63	17.32	8.658	210.84	247.50
Total	87	208.81	27.66	2.966	143.84	399.33

Kruskal-Wallis Chi Square = 6.933; $p = .074$ **DISCUSSION**

Few studies have addressed time in volleyball and none have examined all time segments. In this study a work to rest ratio of approximately 1:1.86 was found for the match and 1:1.5 for the set. On comparing only points and pauses between points, the work to rest ratio is 1:1. Häyrynen et al. (2011) reported a work to rest ratio of 1:4.3 for men's elite matches and 1:3.5 for Under 19 (U19), but did not include time-outs or breaks between sets. According to Palao, Valadés, Manzanares, and Ortega (2014), the

mean work to rest ratio in men's beach volleyball is $1:4.42 \pm 5.73$. Kovacs (2004) reported a work to rest ratio in men's professional tennis of 1:2.67 within games and 1:4.73 within matches.

Häyrynen et al. (2011) found mean values for set duration of 26.3 ± 2.2 minutes for elite teams and 23.5 ± 2.3 minutes for U19 players, indicating a shorter set time by almost 6 minutes between U23 players and elite teams and about 3 minutes between U23 and U19 players. García-Alcaraz, Palao, and Valadés (2012) reported a duration of 24 minutes for elite Spanish teams

and 19.7 to 21.3 minutes for Under 14 (U14), Under 16 (U16) and U19 youth categories, although this study of U23 male players found that sets were 4 minutes shorter than in elite teams, with a small difference of 1 minute compared to U16 and U19. Only U14 had shorter sets, but the main reason could be the large difference in quality of play.

Compared to the results found by Häyrinen et al. (2011), a noticeable shortening of time breaks between rallies is observed, leading to more dynamic games and shorter matches. These authors reported a mean duration of the break between rallies of 23.54 ± 5.55 seconds for elite teams and 19.99 ± 5.70 seconds for U19 European top teams. Sheppard et al. (2007) found 44% of periods between rallies last 12 seconds or less, with a mean value of 14 seconds, compared to the value of 11.57 ± 2.08 seconds found in this study. The period between rallies in relation to *Level of Set Win* increased: between *Walkover* and *Balanced* sets it increased by 0.12 seconds and between *Balanced* and *Tough* sets the increase was 0.62 seconds.

The same tendency appeared in the different phases of the set. Between *Early* and *Middle* phases there was a small difference of 0.01 seconds, but between *Middle* and *Final* phases the increase was 0.34 seconds. The maximum rally duration in this study was 41.50 seconds, whereas in the study by Häyrinen et al. (2011) it was 39.9 seconds for the best 4 teams at the 2008 Olympic Games and 32.2 seconds for the best 4 teams at the U19 European Championship. Sheppard et al. (2007) found that 76.6% of rallies lasted 12 seconds or less, with an approximate mean rally of 11 seconds, although some lasted 3 seconds and others lasted up to 40 seconds. In this study the most frequent point duration was 5-10 seconds (43.5%), followed by points lasting 10-15 seconds (41%) and 15-20 seconds (about 11%), whereas only 3.7% lasted 20-25 seconds. However, in the study by Häyrinen et al. (2011), rallies lasting less than 10 seconds were 84% for elite teams and 86% for U19 best teams, with 14% and 13%, respectively, lasting 10-20 seconds, and 2% of rallies lasting more than 20 seconds for both men and youth players. Sánchez-Moreno, Marcelino, Mesquita, and

Ureña (2015) reported a mean length of 5.0 ± 4.3 seconds for elite teams in world championships matches, compared to 11.50 ± 4.38 seconds in this study. Point duration in the active part of the game was approximately the same as the mean time from the end of the point until the whistle for new serve. A comparison of the results with rally duration in other net and wall sports shows that volleyball is somewhere in the middle. In tennis the rally lasts 5-7 seconds (Kovacs, 2004; Smekal et al., 2001), in badminton 6.2 seconds (Férrandez-Férrandez, de la Aleja-Téllez, Moya-Ramón, Cabello-Manrique, & Méndez-Villanueva, 2013), in beach volleyball 7.25 seconds (Palao et al., 2014) and in squash 18.6 seconds (Girard et al., 2007).

McCutcheon (2013) discussed eliminating technical time-outs in sets to 21 points, replacing them with two 1-minute team time-outs each team can use any time, and if neither team calls a time-out before the 11th point, TV time-out starts automatically. The results for team time-out duration show a large gap between the maximum value (64.33 seconds) and the minimum value (24.33 seconds), and between the maximum and minimum values of time after the whistle for the end of time-out (53 seconds and 1.84 seconds, respectively). The maximum value for before the whistle for time-out was 35.50 seconds and the minimum was 3.77 seconds. With the new rule tested, of 10 seconds until the server starts to serve, the coach has a limit of about 5 seconds to call the substitution, which appears to be a reasonable dynamic for the game and time fluctuation. Before the Brazil Championship there was debate about whether to incorporate free substitution to speed up and simplify the process and allow coaches more freedom for tactical subbing (McCutcheon, 2013). Häyrinen et al. (2011) reported values for time between sets of 217 ± 17 seconds (3.6 ± 0.3 minutes) for elite players and 213 ± 20 seconds (3.6 ± 0.3 minutes) for U19 players. Compared to the results found in this study, the difference is minimal and can be explained by referees strictly adhering to the rules. The shortest parts of sets and matches (sanctions, side change in 5th set and other technical aspects) have little effect on duration. This study found

only 4 matches that had 5th set. The main characteristic of the 5th set is side changing which belongs to resting time for all players. Average duration of the side change was 54.45 seconds, with minimum value of 52.23 seconds, and maximum value of 56.67 seconds. Only 0.16% of set time and 0.14% of match time was spent on side change, which belongs to negligible influential periods. However, every coach can count on those values as a chance to give several advises.

CONCLUSION

Game analysis shows there is scope for limiting pauses between rallies to 10 seconds, giving players adequate time to reach the serving position and 5 seconds to perform the serve. On-the-fly substitutions of libero and middle blockers would need to be more synchronised.

Team and technical time-outs are two parts of rest time that can be adapted to make volleyball a more dynamic sport. The technology for technical time-outs should be applied to team time-outs to establish a clearer, automated time limit. The time after the whistle for the end of technical or team time-outs should be limited to 10-12 seconds so that after this time, all players must be ready on court with the server in position. The whole process will mean that calling for a team time-out will be indirectly limited to about 5 seconds, the time that coaches theoretically had at the U23 Championship in Brazil. These time limits will increase the dynamics of the game and decrease rest time.

The periods between rallies in the *Early* and *Middle* phases were almost identical, but shorter than in the *Final* periods. The difference was about 0.3 seconds, but it would be much longer without the experimental rule of 15 seconds between rallies. This shows that in the *Final* phase, when uncertainty is higher, most teams try to take advantage of longer pauses between rallies. This study can also have an influence on developing the structure of the volleyball game.

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Nothing to declare.

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