UNIVERSIDADE
LUSÓFONA

Centro Universitário de Lisboa
Faculdade de Educação Física e Desporto
Mestrado em Treino Desportivo

CHARACTERIZING THE COMPLEX I IN TOP LEVEL WOMEN'S VOLLEYBALL. AN APPLIED STUDY IN THE TOKYO OLYMPIC GAMES AND VOLLEYBALL NATIONS LEAGUE

Dissertação de Mestrado defendida em provas públicas para a obtenção do Grau de Mestre em Treino Desportivo, orientada pela Professora Doutora Ana Margarida do Amaral Paulo.

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Presidente: Professor Doutor Jorge dos Santos Proença Martins
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2024

Epigraphy

In order to succeed, your desire for success should be greater than your fear of failure.

Bill Cosby

Agradecimentos

A master's thesis is a long journey, which includes a trajectory full of countless challenges, sadness, uncertainties, joys and many mishaps along the way, but despite the lonely process to which any researcher is destined, it brings together contributions from several people, indispensable to find the best course at every moment of the journey. Taking this path was only possible with the support, energy and strength of several people, to whom I dedicate this life project especially.

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Finally, my deep and heartfelt thanks to all the people who contributed to the realization of this dissertation, stimulating me intellectually and emotionally.

Abstract

The aim of this study was to present the characteristics of the performance indicators of top-level female volleyball teams in complex I phase and compare the top-level team's performance. The sample consist of 1026 KI rallies, belonging to 22 women´s matches played in 2021 Tokyo Olympic games and 2021 Volleyball Nations League. The four main variables were: attack efficacy (point, attack blocked) and Setting Zone (reception A and reception B). For data analysis one way-ANOVA was used to compare the teams. For the effect size we used partial eta squared. The level of significance was set at p =.05. The results showed that top level teams on these two competitions played with reception in setting zone A and B Powerful attacks were the most common, facing most of the time double block. Zone 4 was the most recurrently used. Besides teams' performance similarity, they did not follow the same pattern. Team USA, the champion in both competitions, was the team that scored the most in complex I.

Key words: match analysis, volleyball, performance indicators, complex I.

Resumo

O objetivo deste estudo foi apresentar as características dos indicadores de desempenho de equipes femininas de voleibol de alto nível em complexo I e comparar o desempenho das equipas. A amostra consiste em 1026 ralis KI, pertencentes a 22 jogos femininos disputados nos Jogos Olímpicos de Tóquio 2021 e na Liga das Nações de Voleibol de 2021. As quatro principais variáveis foram: eficácia do ataque (ponto, ataque bloqueado) e Zona de configuração (receção A e receção B). Para a análise dos dados, utilizou-se ANOVA unidirecional para comparar as equipes. Para o tamanho do efeito foi utilizada eta parcial ao quadrado. O nível de significância adotado foi p = ,05. Os resultados mostraram que as equipas de alto nível nestas duas competições jogaram com mais receção nas zonas A e B do que na zona C. Ataques potentes foram os mais comuns, enfrentando na maioria das vezes o bloco duplo. A zona 4 foi a mais utilizada. Apesar das similares characteristicas de performance das equipas, elas nao seguem um mesmo padrao de jogo. A equipa dos EUA, campeã em ambas as competições, foi a equipa que mais marcou no complexo I.

Palavras-chave: análise de jogo, vôlei, indicadores de desempenho, complexo I.

List of Abbreviations

AR Attacker role

AT1 First tempo

AT2 Second tempo

AT3 Third tempo

BWT Block out, wipe off or tool

FB Free ball

KI Complex I

MA Middle attacker

OA Opposite attacker

PA Power attack

TDD Tip, dump, or dink

VNL Volleyball Nations League

Índice

List of Tables

List of Figures

Introduction

Collecting and analysing data of game actions is crucial to understand performance in volleyball. The game analysis is a useful tool to understand teams' technical-tactical performance (Afonso, et al., 2017). There are already several contributions in the literature (e.g., Silva et al., 2016; João et al., 2015; López et al., 2022) about volleyball match analysis. Match analysis has progressed significantly in recent years, and it has many purposes such as assisting coaches to determine the advantage or of a player or a team, providing feedbacks to the players after a game on their performance, encouraging players to set personal goals, instructing players during time-outs, provide enough data to design future training sessions and get information to analyze the opponent performance to define the team's strategy (Rodrigues Guerra, 2007).

Volleyball is a challenging team sport with six basic skills - serve, serve-reception, set, block, defence and attack. These skills are used in two types of game phases. The first type, which is known as complex I (KI), is the phase where the team performs serve-reception, set and attack to try to counteract the opponent´s serve. The second type of game phase, known as complex II (KII), includes serve, block, defence, set and counterattack actions (Monteiro et al., 2009).

In top level volleyball, in a given rally, there is an imbalance towards the team in complex I (receiving team) with respect to winning the point (Palao, 2018).The explanation for this imbalance may be the fact that for the team in reception, the ball comes from an action performed far away from the net by one player, and the fact that, at this level, in KI the attack is mostly executed after an ideal serve reception, upon which the setter has the opportunity to organize a fast and combined attack (several players) that will hinder the opposing team´s ability to anticipate and defend, constraining the timely formation of the block (Marelić et al., 2004). Previous studies have shown that at elite senior level, the team in KI has more efficacy than the serving team - 65% vs. 35% (Laios, 2010; Laios & kountouris, 2011).

Performance analysis research in volleyball has for the most part targeted match analysis of adult male competitions. Researches in match analysis of adult female competitions is justified by the apparent distinguishing contrast of the male and female phenotypes in strength, acceleration, and speed due to men´s larger muscle mass (Miller, MacDougall, Tarnopolsky, & Sale, 1993) , height, etc.

There have been studies (Costa, et al., 2012; Kountouris, et al., 2015) comparing performance and effectiveness of different volleyball techniques between males and females. For example, Kountouris and colleagues (2015) published a study related to gender differences

in volleyball performance. The article compared the effectiveness of the five classic skills in volleyball (serve, reception, attack, block, and dig) between men and women in games played in the last four consecutive Olympic tournaments. The findings provided evidence that the game of volleyball is consistently different in men´s games in comparison to women´s games in two distinct skills, serve (men have almost twice as many faulty serves) and attack (men outperform women in successful attacks). Laios (2010) showed that men in 2008 Beijing Olympics volleyball games had significantly higher efficiency in the skills of pass, reception, and attack, while women had significantly higher efficiency in the skill of serve.

Furthermore, the study (Barzouka, 2018) comparing elite male and female volleyball setters in relation to reception quality found that male setters, with excellent serve reception, sets the ball more often to attack zone 1 and attack zone 6 than women, and that both genders set the ball more frequently to attack zone 4. The attack zone 4 is characterized as security attack zone and the attacker receiver as a security player (Araujo et al., 2010).

Studies on performance analysis of teams and athletes in competition, have focused on some performance indicators, including the efficacy percentage of the game actions (Marcelino, 2009; Palao, 2018; Palao et al., 2004). The serve-reception is the first game action in KI. It has an impact on setting performance, in terms of the quality and strategy of the setter, but consequentially in the efficacy of the attack. It is well established that reception efficacy is a predictor of competitive success (Peña et al., 2013) and it is related to attack efficacy (Costa et al., 2014). Effective teams in serve-reception increase their chances of successful attack (i.e., score a point).

Setting follows serve-reception. Setting is performed by a specific player – the *setter*, ideally close to the net - *Perfect zone* according to González-Silva et al. (2020). The setter decides who is going to perform the attack. The quality of reception determines the number of attack possibilities in the offensive organization of the team, and where the setting takes place limits those possibilities, i.e., the further away from the net, the fewer attack possibilities. Correspondingly, less attack possibilities makes the job of the block opposition to the attack easier, since there will be more certainty as to where to go.

Attack action follows setting, and it is the best indicator of success in high level volleyball, since it is the most frequent way of attaining a point (Marcelino, 2009). The attack can be performed from different zones on court and by different attackers, i.e., with different roles in the offensive organization of the team (e.g., Attacker-receiver, opposite attacker, and middle attacker), designated accordingly with the zone where they perform the attack. The

attack also has different attack tempos and different attack types. Costa et. al. (2012) when studied the differences in game partners between male and female youth volleyball suggested that the third attack tempo was typical of female team and the powerful attacks were more often used by men than women.

The aim of this study is to present and compare the performance indicators of top-level teams in complex I in games played in 2021 Tokyo Olympics Games and 2021 Volleyball Nations League (VNL).

Chapter 1. Methods

1.1. Sample

The sample consists of rallies played in two major competitions – 2021 Tokyo Olympic Games and 2021 Volleyball Nations League. Two randomly selected matches of each of the top-four ranked female teams, played in each of the competitions, were sampled for analysis. The teams were United States (First place in both competitions), Brazil (Second place in both competitions, Serbia (Third place in Tokyo Olympic Games), South Korea (Fourth place in Tokyo Olympic Games), Turkey (Fourth place in VNL), and Japan (Third place in VNL). It was analysed the same match for USA, BRA and TUR (USA x BRA and USA x TUR). Altogether, 22 matches were analysed. Three sets from each match were included in the analysis. Marcelino et al. (2009) found diverse dynamics in win determinants according to set type. So, first and last sets were always included in the sample, and in matches with four or five sets the third included set was selected randomly from the remaining sets played. The assessment was performed when the analysed team was in KI phase. It was analysed 12 sets from each team. It was analysed the same sets (6) for USA, BRA and TUR from match USAxBRA and USAxTUR. In total, 66 sets were included in the dataset, resulting in a total of 1206 rallies played.

2. Instruments and procedures

An observational analysis was chosen for this study. The data were collected with a fixed camera positioned at the back of the court from the top perspective, that is, about 7-9 meters behind the end line, with the camera positioned at approximately 3 meters from ground level for better viewing of video scene.

The data were analysed by two experts. One observer, the first author, observed the full sample. She is a level II credited Brazilian coach, with a degree in physical education. Also, she was a professional volleyball player who competed in high level for 15 years. These skills and experiences qualified her as expert observer in volleyball. A second expert observer was available to perform reliability checks. This observer is a level V credited Brazilian coach, with a degree in physical education, eight times youth world champion. He is also an University-level volleyball teacher. His background qualified him as expert to perform the analysis.

To verify the consistency of the observations, the intra and inter-observer reliability was performed. For the observation reliability procedures 8 sets were analysed (10% of the sample). Reliability procedures satisfied the minimum of 0.75 establish in the literature (Fleiss,

2003), with an intra-observer Cohen´s kappa of 0.95 and inter-observer (two observers) Cohen´s Kappa of 0.87.

For the analysis we used the Lince Plus software (Soto et al., 2019) where all the variables´ codes were introduced. Only the KI phase of each rally played was analysed. Before the beginning of each rally the following variables were noted: *set number*, *set result*, and *team* (receiving team). The rally itself was analysed based on three moments: i) Upon reception, as to note the variable *setting zone*; ii) Before the attack, to note the following variables: *attack zone*, *attacker role*, *attack tempo* and *opposition*; and iii) in the end of the rally, to note the variables: *attack type*, *attack target zone* and *attack efficacy*. The data was exported to an excel sheet. In the excel sheet each line corresponded to a rally played, and each column to one of the variables described next.

3. Variables

3.1. Setting Zone

The setting zone is defined as the placed on the court where ideally setting occurs. Setting zone categorization was adapted from González-Silva et al. (2020) and comprises the following categories: *Perfect zone* (A), a two by six meters area, located one and a half meter from the right side-line and one and a half meter from the left side-line and two meters from the net; the setter has all the attack options; *Acceptable Zone* (B), a nine by one meter area, the remain area in front zone; the setter has a certain degree of difficulty to set; and finally, the *Not acceptable zone* (C), all the remaining area in the back zone.

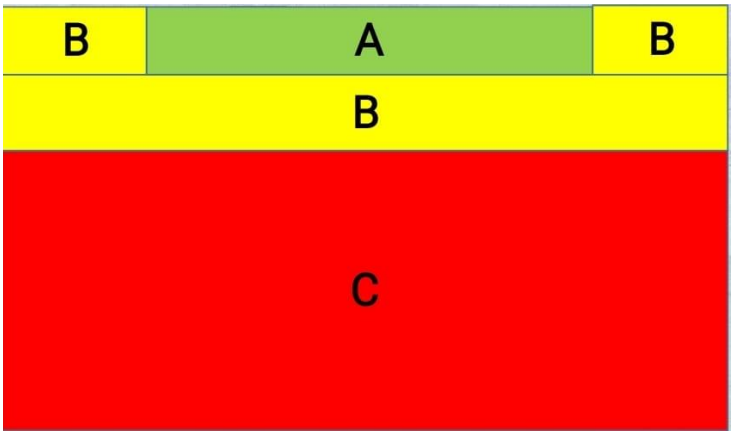

Figure 1- Setting zone categories.

3.1.1. Attack Zone

The attack zone corresponds to the place from where the attackers perform the attack action. The definition of attack zones was based on the Official Volleyball Rules 2017-2020, approved by 35th FIVB congress 2016. This variable comprises the following categories: *attack zone 1*, the attack zone (back row) at right side of the net to perform the second line attack; *attack zone 2*, the attack zone (front row) at right side of the net; *attack zone 3*, the attack zone (front row) in the centre of the net; *attack zone 4*, the attack zone (front row) in the left side of the net; and finally, the attack *attack zone 6*, the attack zone (back row) in the centre of the net to perform the second line attack.

3.1.2. Attacker role

The attacker role relates to the functional specialization of players within the team. There is the *Attacker-receiver*, which corresponds to the players that in most team rotations (at least five out of the six possible) attacks and blocks on the front left side of the court. These players are always involved, at this level of competition in reception. Another role is that of the *Opposite Attacker*, which corresponds to the player that attacks and blocks for the most part on the right side of the court (twice in zone 2, and three from the back court). Lastly, we have the attacker role *Middle Attacker*, which corresponds to the players positioned in-between the two other attackers at the net (midfrontal position).

3.1.3. Attack tempo

The attack tempo corresponds to the relationship between the attacker, the set, and the ball. The categories used were adapted from Costa et al. (2017): *Attack tempo 1*, the attacker takes off during or immediately after the setter contacts the ball; *Attack tempo 2*, the attacker starts his approach after the ball is set; and *Attack tempo 3*, the attacker waits for the ball to reach its trajectory peak and only then begins his approach.

3.1.4. Attack opposition

The opposition corresponds to the number of blockers the attacker faces in his attack action (adapted from Costa et al., 2014). The following categories were established: *No block*, corresponds to an attack with no block opposition; *Individual block*, which corresponds to an

opposition of one blocker; *Double block,* which corresponds to an opposition of two blockers; and *Triple block,* that corresponds to the presence of three blockers.

3.1.5. Attack type

The variable attack type relates to the different ways the attack action can be performed. The attack type was categorized following the suggestion of Costa et al. (2011) and Costa et al. (2017).

The following categories were included: *Powerful attack* - the player performs a powerful attack by causing a descending trajectory; *Block out, wipe off or tool* (BWT) - attack that is deflected off an opponent´s block; *Tip, dump, dink* (TDD) - Attack which the player uses the pads of their fingers to contact the ball and control the direction it is sent; *Placed attack* - refers to an attack with controlled force on the ball directing it to a space on the opponent's half-court; and *Free ball* - when a team sends the ball to the opponent´s court, and it is easy to play for the defensive team.

3.1.6. Attack efficacy

The attack efficacy relates to the outcome of the attack action. The categories were established according to Costa et al. (2017): *Point* – a direct point from the attack as the ball hits the opponent's court, or is deflected by the block, or when the defence was unsuccessful, or if a block error occurred; *Blocked attack* – when the attack is blocked, resulting in a point to the blocking team; *Attack Errors* – when the attacked ball goes out, to the net, or if a lift foul was called; and finally, *Continuity* - when the attack action did not result in a terminal action, and the rally continues.

4. Data Analysis

Initial nominal data was converted into quantitative data. For each category of the variables detailed previously, the percentage of the total sample for each set played, by a given team, was computed (N=72). The description of the full sample and of each team for each variable category is presented in terms of means and standard deviations. Teams were compared using a one-way ANOVA. For the effect size we used partial eta squared: small = 0.01; medium = 0.06; and large = 0.14, as proposed by Field (2005).

Chapter 2. Results

In the present study we aimed to analyse complex I. For that we looked at *Setting Zone, Attack Zone, Attack Role, Attack Tempo, Opposition, Attack Type and Attack Efficacy* with respect to the national teams USA, BRA, SRB, KOR, TUR and JAP present in 2021 Tokyo Olympic Games and 2021 Volleyball Nations League. A description of the mains prominence results for each variable are presented in terms of means and standard deviation, for the all sample, and inferentially, comparing teams.

2.1 Setting zone

Regarding the setting zone, in KI phase (Figure2), the setting zone A was the most frequently sought setting zone (55.71%±14.67), seconded by Zone B (23.63%±11.69), and finally Zone C (20.94%±11.41). Among all teams TUR was, on average, the team with the highest frequency of Zone A receptions (62%±12.31) followed by USA (60.58% ± 15.93) and JAP (58.58% ± 15.59). SRB and USA differed from the rest of other teams with zone C being the second most frequent setting zone (SRB: 27.25%± 89.29; USA: 22.92% ± 14.88) instead of zone B (SRB: 19.92% ± 11.90; USA: 17.42% ±9.16).

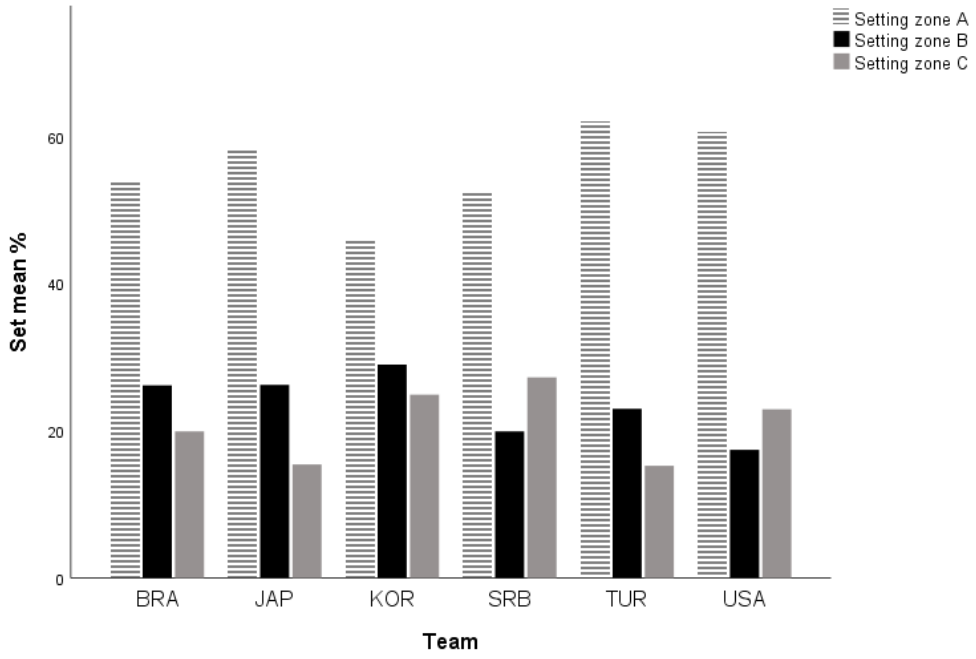

Figure 2- Set percentual average of setting zone categories, per team

A One-way ANOVA was performed to compare the effect of *Team* on *Setting zone* categories *A*, *B*, and *C*. As shown in Table 1, the effect of *Team* was only significant for *Setting zone C*, with a large effect size. Nonetheless, pairwise *post hoc* analyses using the Bonferroni criterion were not able to significantly discriminate between the teams.

Table 1 - One-Way analysis of variance for the effect of team in setting zone categories

Setting zone	SS	MS	$F_{(5, 71)}$	*p*	η_p^2
A	2060.79	412.16	2.06	.08	.14
B	1139.13	227.83	1.76	.14	.12
C	1481.61	296.32	2.52	.04	.16

Significant level set at .05; SS: Sum of Squares, MS: Mean Square

2.2 Attack zone

In relation to the attack zone, as we can see in Figure 3, the most sought out during attack zone in KI was *attack zone 4* (42.71%±14.40), followed by attack *zone 2* (28.21%±12.92), and *attack zone 3* (15.26%±9.14). Both Attack zones from the back row – zone 1 (7.13%±7.19) and zone 6 (7.08%±7.94), were the two least sought attack zones. KOR was the team that most frequently used zone 4 to attack (53.8% ±17). On the contrary, TUR was the team that least attacked from *attack zone 4* (32.7% ±15). KOR and USA were the teams that least used *Attack zone 3* to attack (KOR: 9.08% ±7.20; USA: 9.25%±4.20). On the other

hand, USA was the team with the highest percentage of attacks from zone 2 (36% ± 17.3).

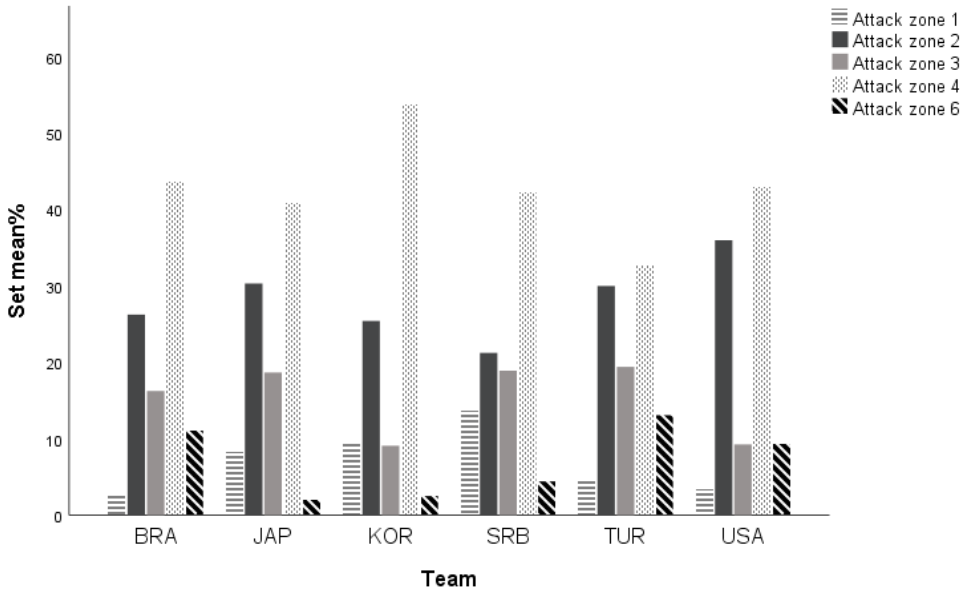

Figure 3- Set percentual average of Attack Zone categories, per team

A One-way ANOVA was performed to compare the effect of Team on *Attack zone* categories attack *zone 1*,attack *zone 2, zone 3, zone 4* and *zone 6*. As shown in Table 2, the effect of *Team* was significant for *zone 1*, *zone 3*, *zone* 4 and zone 6, with a large effect size for all categories.

Table 2 - One-Way analysis of variance for the effect of team in Attack zone categories

Attack zone	SS	MS	F (5, 71)	*p*	η_p^2
Zone 1	1059.45	211.89	5.35	<.001	.29
Zone 2	1541.79	308.35	1.97	.09	.13
Zona 3	1410.07	282.01	4.11	.003	.24
Zona 4	2751.95	550.39	3.03	.01	.18
Zona 6	1322.16	26443	5.52	<.001	.29

Significant level set at .05; SS: Sum of Squares, MS: Mean Square

Post Hoc Bonferroni tests for multiple comparisons found that the mean value of zone 1 attack was significantly higher for SRB, when compared with BRA (p=.001; 95% CI [2.93, 18.57]), TUR (p=.015; 95% CI [1.01, 16.66]), and USA (p=.002; 95% CI [2.51, 18.16]).

Post Hoc Bonferroni tests for multiple comparisons found that the mean value of zone 3 attack was significantly higher for TUR, when compared with KOR (p=.049; 95% CI [.03, 20.64]). Inversely, Post Hoc Bonferroni tests for multiple comparisons found that the mean value of zone 4 attack was significantly higher for KOR, when compared with TUR (p=.004; 95% CI [4.41, 21.167]). Finally, Post Hoc Bonferroni tests for multiple comparisons found that the mean value of zone 6 attack was significantly higher for BRA, when compared with JAP (p=.033; 95% CI [.04, 17.64]), and higher for TUR, when compared with SRB (p=.047; 95% CI [.06, 17.27]).

2.3. Attacker role

In KI phase, the most used attacker was the attacker-receiver (44.67%±14.28), followed by the *Opposite attacker* (33.78%±13.40) and finally the *Middle attacker* (22.19%±11.68). KOR (52.50%±17.56) was the team with the highest frequency of attacks performed by the *attacker-receiver*, followed by USA (49.33±14.5). The inverse occurred to TUR that used the *Attack receiver* the least (34%±14.44).

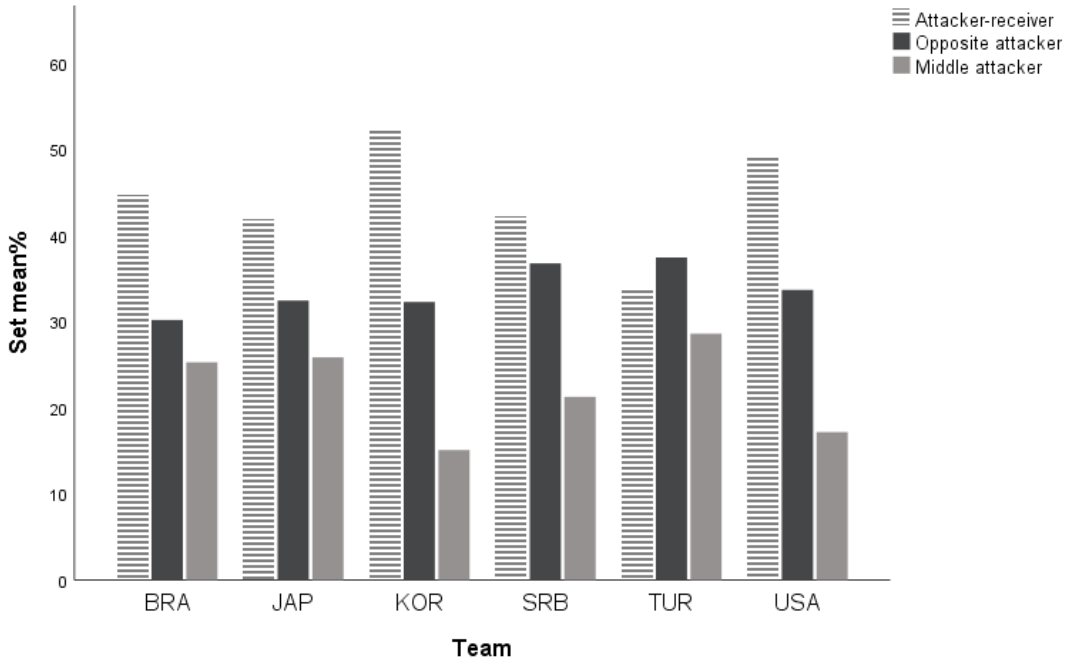

Figure 4 - Set percentual average of Attacker Role categories, per team

A One-way ANOVA was performed to compare the effect of *Team* on *Attacker role* categories *Attacker-receiver*, *Opposite Attacker*, and *Middle attacker*. As shown in Table 3, the effect of *Team* was significant for *Attacker-receiver* and *Middle attacker*, with a large effect size for both categories.

Table 3 - One-Way analysis of variance for the effect of team in Attack role categories

Attack role	SS	MS	F(5, 71)	*p*	η_p^2
Attack receiver	2509.83	501.96	2.55	.03	.16
Opposite attacker	471.77	94.35	.50	.77	.03
Middle attacker	1681.61	336.32	2.77	.02	.17

Significant level set at .05; SS: Sum of Squares, MS: Mean Square

Post Hoc Bonferroni tests for multiple comparisons found that the mean value of attacks performed by the attacker-receiver was significantly higher for KOR, when compared with TUR (p=.029; 95% CI [1.06, 35.94]).

2.4. Attack tempo

The most frequent attack tempo used by all teams was the attack tempo 2 (54.03%±19.58), followed by the attack tempo 3 (28.78%±18.77), and finally, the least frequent was attack1 tempo (17.07%±9.55). The team with the highest frequency of second tempo was KOR (65.92%±16.52) followed closely by USA (64.92%±15.83). The team with the least frequent second tempo was SRB (31.17%±19.06). JAP (21.83%+-10.92) was the team that most frequently used *first tempo* compared to others. USA and KOR were below the full sample average with respect to the use of first tempo (10.92%±5.33 and 11.33%±8.52, respectively).

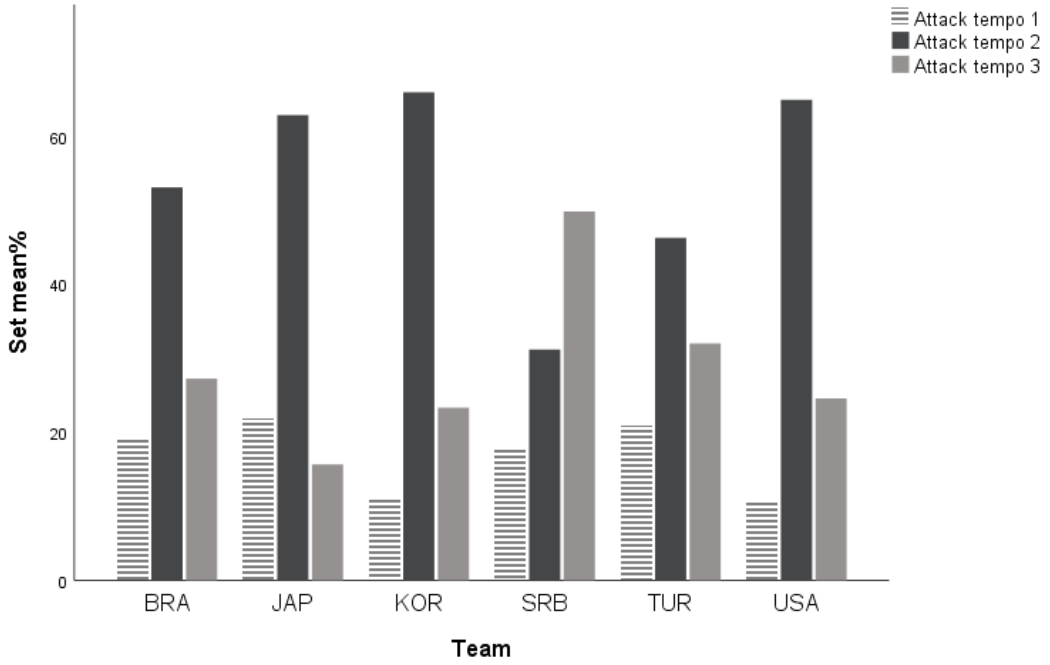

Figure 5- Set percentual average of Attack Tempo categories, per team

A One-way ANOVA was performed to compare the effect of *Team* on *Attack tempo* categories *Attack tempo 1*, *Attack tempo 2* and *Attack tempo 3.* As shown in Table 5, the effect of *Team* was significant for the three attack tempo categories, with a large effect size.

Table 4 - One-Way analysis of variance for the effect of team in Attack tempo categories

Attack tempo	SS	MS	F(5, 71)	*p*	η_p^2
First Tempo	1369.90	273.98	3.54	<.001	.21
Second Tempo	11057.61	2211.52	9.03	<.001	.40
Third Tempo	8102.27	1620.45	6.32	<.001	.32

Significant level set at .05; SS: Sum of Squares, MS: Mean Square

Post Hoc Bonferroni tests for multiple comparisons found that the mean value of second tempo was significantly higher for KOR, when compared with TUR (p=.045; 95% CI [.21, 39.12]), and significantly lower for SRB, when compared with BRA (p=.016; 95% CI [2.46,

41.37]), JAP (p<.001; 95% CI [12.21, 51.12]), KOR (p<.001; 95% CI [15.30, 54.20]) and USA (p<.001; 95% CI [.14.30, 53.20]).

Post Hoc Bonferroni tests for multiple comparisons found that the mean value of third tempo was significantly higher for SRB, when compared with BRA (p=.014; 95% CI [2.68, 42.49]), JAP (p<.001; 95% CI [2.68, 14.26]), KOR (p=.002; 95% CI [6.60, 46.40]) and USA (p=.004; 95% CI [5.35, 45.15]).

2.5. Attack opposition

Regarding the attack opposition, more than two thirds of the attacks in KI phase were against double block (70.85%±15.04), followed by simple block (23.86%±14), no block (3.6%±4.52) and, finally, triple block (2.78%±11.7). The team of KOR was the one that most frequently faced a double block (78.25%±8.98). BRA was the team that attacked the most against *triple block* (8.25%±27.04) during KI phase. On contrary, JAP was the only team that never faced a triple block.

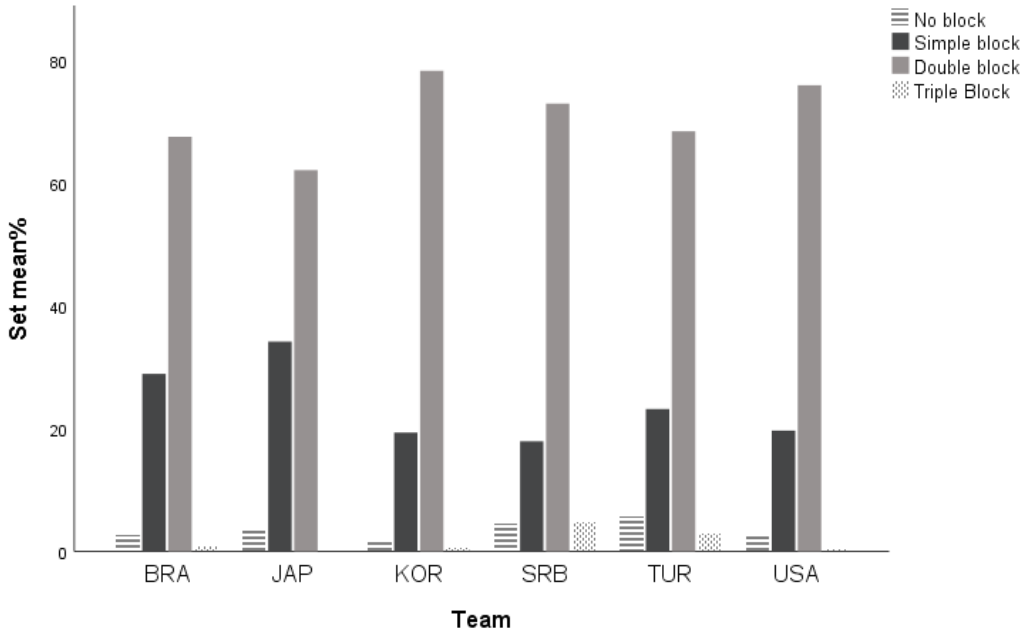

Figure 6 - Set percentual average of Opposition categories, per team

A One-way ANOVA was performed to compare the effect of *Team* on *Opposition* categories *NO block*, *Single block*, *Double block,* and *Triple block*. As shown in Table 7, the effect of *Team* was only significant for *Simple block*, with a large effect size.

However, pairwise *post hoc* analyses using the Bonferroni criterion were no able to significantly discriminate between teams.

Table 5 - One-Way analysis of variance for the effect of team in Opposition categories

Opposition	SS	MS	F(5, 71)	*p*	η_p^2
No block	104.90	20.98	1.02	.40	.07
Simple block	2468.11	493.62	2.84	.02	.17
Double block	2144.40	428.88	2.03	.08	.13
Triple block	628.94	125.78	.91	.47	.15

Significant level set at .05; SS: Sum of Squares, MS: Mean Square

2.6. Attack type

Most frequent attack type performed during KI phase was by far the *Powerful attack* (76.63%±11.01), followed by TDD (13.96±9.19), *BWT* (3.03%±4.9) and PLACED attack (4.71±5.67). Free ball was the least used Attack type (1.86±2.95). SRB and BRA were the teams that had the highest frequency of PA (79.67%±8.25 and 79.08%±9.34, respectively). KOR (16.17%±9.98) and TUR (15.92%±6.72) were the teams that performed TDD the most.

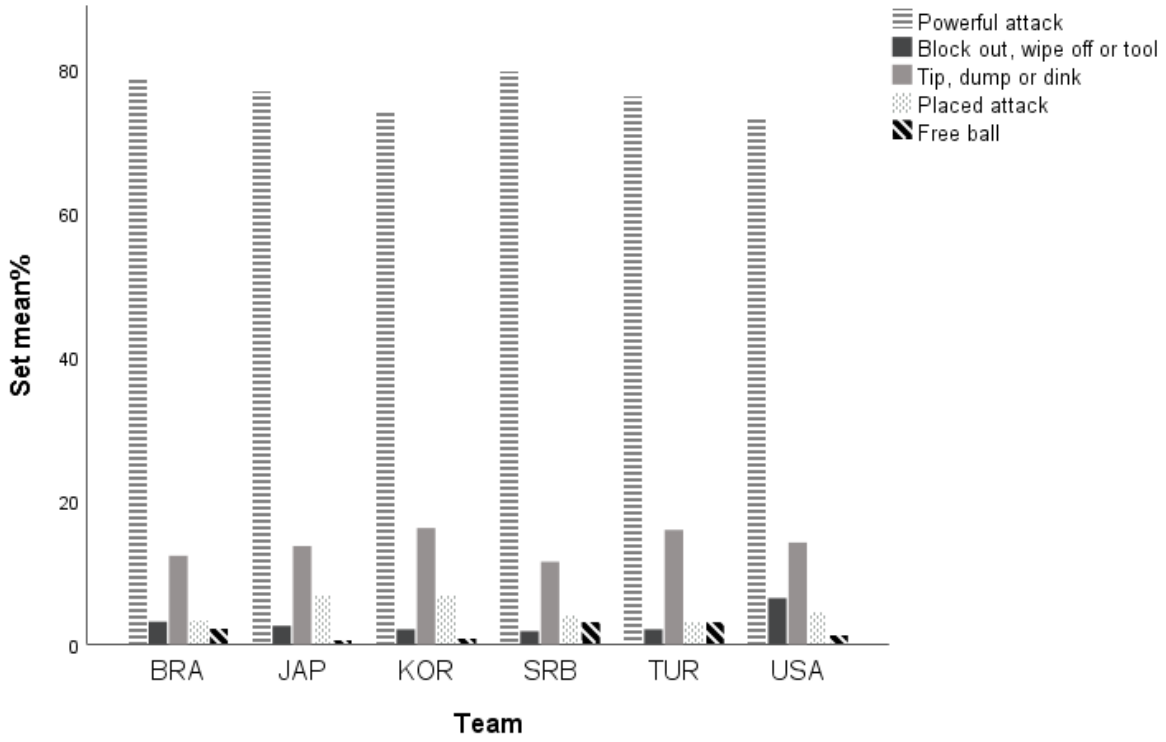

Figure 7- Set percentual average of Attack type categories, per team

A One-way ANOVA was performed to compare the effect of *Team* on *Attack type* categories *PA*, *BWT*, *TDD*, *PLACED* and *FB*. As shown in Table 8, the effect of *Team* was not significant *for any of the categories*.

Table 6 - One-Way analysis of variance for the effect of team in Attack type categories

Attack type	SS	MS	F(5, 71)	*p*	η_p^2
Power attack	356.12	71.22	.56	.72	.04
Block out	178.94	35.78	1.49	.20	.10
Tip	210.29	42.05	.47	.79	.03
Placed attack	165.79	33.15	1.03	.40	.07
Free ball	75.11	15.02	1.82	.12	.12

Significant level set at .05; SS: Sum of Squares, MS: Mean Square

2.7. Attack efficacy

Attack continuity was the most frequent outcome (44.60%±13.42) followed closely by *Attack point* (41.96%±13.25). *Attack blocked* (6.86%±6.65) and *Attack error* (6.67%±6.41) were the outcomes that occurred the least. USA was the team that scored the most (*Attack point*: 47.08%±15.03) followed by BRA (45.17%±12.43) and SRB (44.25%±12.01). On the other hand, the team that scored the least, in KI phase, was JAP (32.92%±11.85). KOR was the team with the higher percentage, on average, of the Attack *continuity* outcome (54.25%±13.96) and USA, the team with the least continuity outcome (39.75%±13.42). KOR had the highest percentage, on average of blocked attacks (8.58%±8.29), and BRA was the least blocked team (5.33%±4.57), in KI phase. TUR was the team that had the highest percentage, on average, of attack errors (9%±8.31), whilst KOR had the least attack errors (4.58%±5.18).

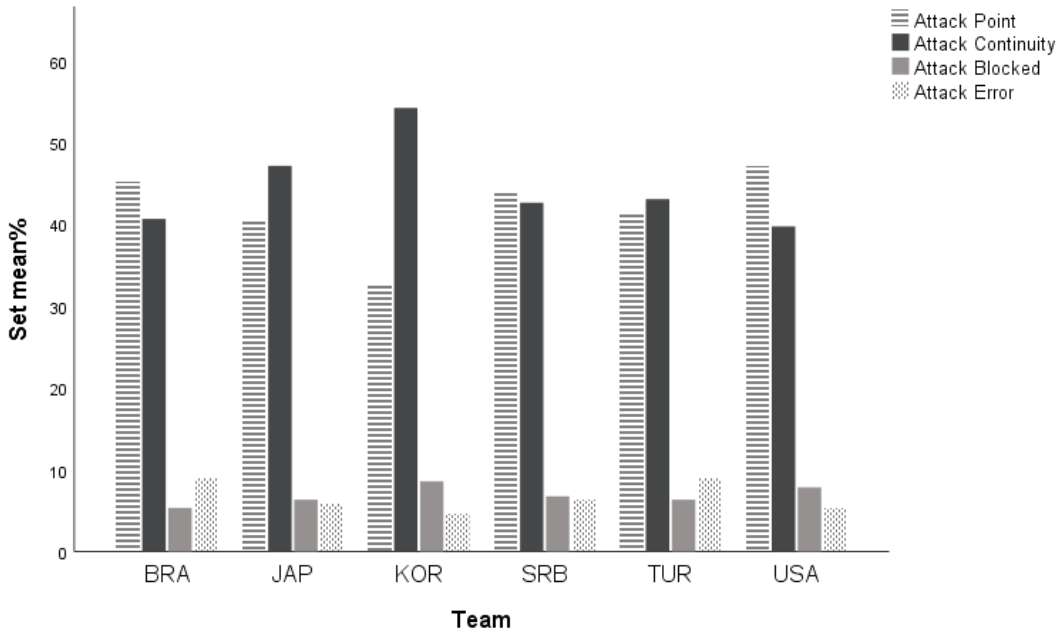

Figure 8 - Set percentual average of Attack Efficacy categories, per team

A One-way ANOVA was performed to compare the effect of *Team* on *Attack efficacy* categories *Attack Point, Continuity, Attack blocked,* and *Error*. As shown in Table 9, the effect of *Team* was not significant for any category.

Table 7 - One-Way analysis of variance for the effect of team in Attack efficacy categories

Attack efficacy	SS	MS	F(5, 71)	*p*	η_p^2
Attack Point	1501.95	300.39	1.80	.12	.12
Attack Continuity	1736.90	3047.38	2.07	.80	.13
Attack Blocked	81.77	16.35	.35	.87	.02
Error	211.33	42.26	1.02	.40	0.7

Significant level set at .05; SS: Sum of Squares, MS: Mean Square

Chapter 3. Discussion

The aim of this study was to analyse the performance indicators/game actions in KI of top-level teams in 2020 Olympic games and 2021 VNL competition. The descriptive analysis of the data showed that the best top-level teams in these both competitions have many similar features in KI phase such as high percentage of serve reception in *setting zone A* and *B,* high percentage of attacks performed in *attack zone 4* and *2,* great use of attack *tempo 2,* high percentage of *powerful attack* and high percentage of attacks performed against *double block.*

Serve-reception in the *Perfect zone A* and *B* were the most frequent which is expected in this level of competition. González-Silva et al. (2020) targeted characteristics of skills that determine setting efficacy and suggested that the quality of serve-reception is an important factor for team´s success. Moreover, reception efficacy has been shown to be particularly relevant in competitive volleyball (see Paulo et al., 2018) because the attack success correlates positively with an excellent serve reception once both variables increase the probability of scoring (Mesquita et al., 2007).

Related to Attack zone, the most used zone is zone 4, this finding agrees with the findings of Palao et al. (2007) in the study to find out the tendencies of peak performance spike which confirm the higher use of attack zone 4 and 2. Female volleyball teams mostly attack in zones close to the net (Z2, Z3 and Z4) to increase the chance to earn a point. Castro et al. (2010) argue that further away the opposite team´s offensive action is from the net, the easier it is to produce a better quality first touch and then to build well organized attack, for this reason women volleyball use less back row attacks.

As to attack Opposition, the results show that most of attacks performed in KI phase was against double block. Our results reflect those found in other studies (Araujo et al., 2010; Mesquita et al., 2007) related to attack opposition.

The Attack type most used in these two high-level competitions was the Powerful attack with the highest percentage values of occurrence. BRA and SRB were the teams closer to 80% of use of the *Powerful Attack* in KI. Previous studies have demonstrated clear superiority of powerful attack over the opponent´s defensive system (Palao et al., 2007; Palao et al., 2018). The Power attack decreases the probability of *Attack continuity*, which increases the chances to score a point.

As for the attack result, regardless the attack efficacy, it was observed that the continuity is the most frequent outcome, and the Attack Error was less frequent. The attack point was the outcome most frequent of the finalist teams of both competitions (BRA and USA).

However, the gold medal team (USA), in addition to high frequencies of attack point in KI phase, had also small frequencies in attack error. This suggests that in high-level competition, where the team's level of performance is close, the team who has less error and attack efficacy in KI phase might have greater chances to win the competition.

Besides the high similarity of teams performance in KI, each team has its particularity, for instance the USA team, score the most in KI and it is one of the teams with serve reception more frequent in zone C than zone B (see figure 1). Even having more receptions in *Setting Zone, A and C, USA team* scored (*Attack Point*) more in complex I compared to JAP that had more reception in *Setting Zone A* and *B.* The American team was the team that won both competitions and played most of the time by attack zone 2 and attack zone 4 (attack role AR, Attack role OP and MA) but with a great speed of the game maybe due to the high percentage of serve reception in setting zone A. The USA team used more attacks in *attack zone 4 and 2* and performed less attack in *attack zone 3* compared to other teams. In this actual study the values of the remaining of the zones must be interpreted carefully because zone 2 is used also by middle blockers to do one-leg attacks. USA was one of the teams that had more frequency of attacks in zone 4 even with a good percentage of reception in the perfect zone (A), this high use of this zone may be based on the quality of the players that use to play in this attack zone, for instance USA has the competition most valuable player (MVP) playing in this Zone.

SRB team is one of the top teams in international volleyball, even with most of its serve-reception in the *Perfect zone A* used more *attack tempo 3* and *2*. One of particularity of the Serbians was the attacks in attack zone 1 more frequently compared to the other teams. This may be because SRB has a left-hand, tall and athletic player performing in this zone. Perform attack from this attack zone is a characteristic of elite male players as Barzouka (2018) found in her study where under excellent reception conditions men set the ball to zones 1 and 6 more frequently compared to women.

In relation to Attack role, the analysis comparison between teams showed that TUR was the team that used the most the *role MA* and *attack tempo 1* during KI, maybe because TUR was the most efficient team in the reception in *setting zone A.* Palao et al. (2007) have noticed that the use of quicker attack tempo occurs mainly in favourable conditions as in successful receptions and defence, which allows more options for the setter to choose from. The *attack tempo 1* and *attack tempo 2* are considered fast attacks, and their use has been shown to increase the attack efficacy regardless of game phase (Palao et al., 2007). In female volleyball attack tempo 1 is less used comparatively to male volleyball (Costa et al., 2017). Asterios et al., (2009)

have analyzed World League matches (men) and have perceived that deploying fast attacks was a predictor of winning the match. The TUR team was the team with the lowest percentage of attacks performed in attack zone 4 because the team used more the opposite attacker than attacker receiver. TUR had more attack continuity than attack point as outcome in KI. The Turkish team was the team that had the highest percentage, on average, of attack errors in KI, this may be due to the high usage of quick attacks which requires precises settings.

JAP is traditionally known by its game speed, and in this study the result shows that JAP was the team that most frequently used *first tempo* compared to others, consequently the attackers faced, most of the time, simple block and they never faced triple block. Although facing simple block, JAP was less efficient with few attack errors but with a percentage of attack continuity higher than attack point in KI. This condition maybe it is due to the fact Japanese players are not tall or athletic enough to perform attacks strong enough to score.

BRA was the team that performed the most attacks in *Attack zone 6* compared to SRB, JAP and TUR. The use of this attack zone by BRA may be related to use of opposite attacker and attacker receiver attacking from this attack zone. Its performance was characterized by high percentage of serve reception in *setting zone A and B*, attack performed more in attack zone 4, few attack errors and more attack point than attack continuity in KI.

KOR team performance was characterized by high usage of attack zone 4, high percentage of attack continuity as attack outcome and a few attack errors in KI. Korean team was the team with the highest percentage of attack against double block, maybe can be explained by the high usage of attack zone 4, in this situation it is easy to predict where to block.

Conclusion

This research examined the characteristics of performance indicators of high-level female teams in high-level volleyball competitions. It was found that the high-level competitive teams have some similar features in KI. Some of similarity is the high percentage of reception in *setting zone A* and *B,* attacks performed frequently in *attack zone 4* and *2,* great use of attack *tempo 2*, high percentage of *powerful attack,* high percentage of attacks performed against *double block* and *attack continuity as outcome,* but the teams do not follow the same pattern because of the individual characteristics of players. There is team that depend on their attacker receiver (USA), other depends more on its opposite attacker (SRB), other depend on its faster game (JAP).

The finalist teams had higher frequency of attack point in KI phase and small frequency in attack error. This suggests that in high-level competition, where the team's level of performance is close, the team who has less error and attack efficacy in KI phase might have greater chances to win the competition.

Practical implications

This study presents a valid contribution to coaches and athletes related to performance indicators on top-level teams in KI phase. The performance analysis in sports games has made possible to promote the development of training methods that guarantee greater specificity and therefore greater transferability. The information may be useful to coaches to be more specific when establishing goals. For instance, while in training the percentage attack efficacy in KI, the percentage of error that a team is allowed to have to achieve the level of top performance teams, or train more attacks after receptions in setting zone C.

Future Research

Based on possible relevant performance indicators evidenced by the top-level teams in this study, another study could be done to try to identify which performance indicators predicts winning in top-level female volleyball.

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