

## The relationship between serve-receive quality and attack performance across different age categories in women's elite volleyball

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### Abstract

The objective of this study was to examine and compare the potential correlation between serve-reception accuracy and subsequent attack effectiveness among senior, U20 and U18 age groups in top-level women's volleyball. The study focused on senior national women's teams participating in the 2023 European Championship in Group D and the U20 and U18 teams participating in the 2024 European Championship qualification rounds. A total of 1,967 attacks across 84 sets in 22 matches were analyzed. Data were collected using the specialized Data Volley Professional 3.2.1. software. The Chi-Square Test and contingency coefficient C were utilized to identify associations, while the Z-test was employed to ascertain differences in attack quality following accurate and inaccurate serve-reception across various skill levels. The results were evaluated at the 5% statistical significance level. We found a statistically significant relation ( $p < 0.05$ ) across all studied age categories (U18  $\chi^2 = 38.6463$ ,  $C = 0.1211$ ; U 20  $\chi^2 = 13.0766$ ,  $C = 0.1458$ ; senior women  $\chi^2 = 62.5291$ ,  $C = 0.3069$ ). The results of the statistical analysis confirmed the assumption of a higher incidence of excellent attack after a positive serve-reception in all the studied categories compared to attacks after a negative serve-reception. Statistically significant differences were also found in most other levels of attack quality assessment ( $p < 0.05$ ), except for erroneous attacks, where we found no significant differences in attack after positive and negative serve-reception in all of the categories examined ( $p > 0.05$ ). Statistically insignificant differences were found for positive attacks (+) in the U20 and U18 categories ( $p > 0.05$ ). The contingency coefficient of senior females was the highest (45%) of all the possible coefficients in the given contingency table ( $C_{\max} = 0.86602$ ), while it was 27% for the U20 and 19% for the U18 category. These results suggest a decreasing closeness of the relation between serve-receive accuracy and the qualitative characteristics of the subsequent attacking stroke from the oldest age category to the youngest one, thus confirming our hypothesis. The results can be useful in evaluating the performance of players in matches and serve as model characteristics of the team's play in side-out transition in the studied age categories.

**Keywords:** volleyball, age categories, reception, attack, comparative analysis

### Introduction

It is a characteristic of contemporary volleyball that attack efficiency is the main factor that decides the winner of the match and the team's position in the competition (Přidal, Hančák 2012, Mesquita et al., 2013, Campos et al. 2014, Costa et al. 2016, García-Alcaraz, Marcelino, 2017, Drikos et al. 2019, García-Alcaraz et al. 2016; García-Alcaraz et al., 2020). However, apart from the technical and tactical skills of the attackers, taking into account other factors such as their somatic and condition parameters current discipline and mental condition, this is also influenced by the quality of their previous game activities – passing and receiving a pass (Přidal et al. 2023). The more accurate, quicker and surprising the pass, the higher the probability of an effective attack and a point gain. Accurate passing is important because it allows the passing player to use the full range of passing options to create favourable game situations for the attackers to finish the attack. Inaccurate passing limits passing variability and gives an advantage to the opponent, as confirmed for men, e.g. by Papadimitiou et al. (2004) and Patsiaouras et al. (2010). Thus, the accuracy of the serve-reception influences the possibility of all players being involved in the attack (Costa and Freire, 2017; Araújo et al., 2009). Research in this area has also been conducted by Monteiro et al. (2009), Paulo et al. (2016), and Conti et al. (2018), who found a relationship between the quality of serve-reception and the quality of attack. The effect of the serve-reception alone on a team's success in a set is not often confirmed directly (Palao et al 2004), as passers are able to compensate for the passing ball's accuracy to some extent. However, as their accuracy decreases, they cannot stick to the prepared strategy of attacks, exploit the availability of their attackers and the weaknesses in the opponent's defence. This is confirmed by empirical experience and some research (Bergeles et al 2009). The studies cited above focus primarily on men's high-level volleyball and less so on women's high-level volleyball. The investigation into the differences between men and women in terms of the quality of playing activities has been addressed by Palao et al (2004) and Drikos et al (2019). They found that the most important indicator of team success for men is an excellent attack after receiving the serve and for women it is the same plus the counterattack. The lower age

categories are of even less interest to researchers. In men's volleyball, Garsia-Alcaraz et al. (2014) found that the serve effectiveness decreases with increasing age, while on the other hand Paulo et al. (2018) reports a higher efficiency of serve-reception. The aim of the study by Garcia de Alcaraz, Marcelino (2017) was to investigate whether there are differences in the quality of performance of game activities in different age categories of men from U14 to the high-level seniors, depending on the balance of matches. Significant differences were found especially in the younger age categories in both balanced and unbalanced matches. Works comparing the success of an attack in relation to the serve-reception or following a field defence have shown the importance of pass accuracy on attack efficiency, opportunities for attack and type of attack. Garcia de Alcaraz et al (2015) analysed the technical-tactical profile of the attack and counter-attack of male players in different age categories from U-14 to the senior international level. The results showed a significant increase in the number of fast attacks at older categories, an increase in the speed of attacks in the first and second tempo, which contributed to higher efficiency. Costa et al (2011) Identified the determinants of offensive tactics' effectiveness in elite young men's volleyball. This study showed that an explosive offence increased the chances of scoring when attacking after both receiving a serve and playing defence in the field (transition). The 1<sup>st</sup> tempo offence increased the scoring chances after playing defence in the field. Zapletalová and Mašek (2011) dealt with the search for the relationship between the accuracy of serve-reception and the effectiveness of the attack stroke in various age categories. The authors found a significant relationship in the cadet, junior and senior female categories, while the closeness of the relationship decreased with age.

The aim of our research was to identify and compare the selected quantitative and qualitative characteristics of the attack phase of play of U18, U20 and senior women's teams following a serve-reception based on an investigation into the relationship between serve-reception accuracy and the subsequent quality of the attack. Our hypothesis was that we would find significant associations between the accuracy of serve-reception and the subsequent quality of the attack in all the age categories, with a closer relationship in the higher age category.

## Material & methods

### Participants

The objects of our investigation were the national U18, U20 and senior women's volleyball teams. In the U18 and U20 categories, we studied the teams that finished in the top six places in the first round of the 2024 European Championships qualification, organized by the Central European Volleyball Association (MEVZA). In both categories, we studied the teams from Croatia, Slovenia, Slovakia, Hungary, Austria and the Czech Republic. In the senior category we studied the matches between the teams in qualification group D for the 2023 European Championship – Slovakia, Spain, the Netherlands and France. In total, we evaluated 22 matches and 84 sets, thereof 8 matches in the U18 category, 8 matches in the U20 category and 6 matches in the women's category. In total, we registered 1,967 attacks, of which 1,171 followed a positive serve-reception and 796 followed a negative serve-reception. The basic characteristics of the dataset are presented in Table 1.

**Table 1 Characteristics of the dataset**

Characteristics	U 18	U 20	Women
	Mean ± SD	Mean ± SD	Mean ± SD
	Min and max	Min and max	Min and max
Calendar age (years)	15.9 ± 0.51	18.5 ± 0.56	26.3 ± 1.38
	14 – 17	16 – 19	19 – 38
Body height (cm)	174.6 ± 4.43	179.1 ± 1.38	178.3 ± 2.4
	161 – 191	169 – 197	169 – 201
Body weight (kg)	65.2 ± 3.23	69.4 ± 2.17	75.9 ± 2.96
	44 – 85	51 – 87	56 – 88
Spike reach (cm)	287.8 ± 3.54	288.5 ± 2.5	300.1 ± 6.68
	265 – 305	271 – 310	280 – 313

### Procedures

The variables studied were age category, attack after a positive serve-reception and after a negative serve-reception (in side-out transition). A positive serve-reception is a reception where the passer passes between zones 2 and 3 and can use all types of passes and involve all offensive players in the attack. A negative pass-reception means that the passer can only engage the attacking players on the sides of the net. We evaluated the quality of the attacking stroke using four degrees of quality:

(#) Point gained by attack

(+) A positive attack after which the defending team had to return the ball to the attacking team as a free ball

(-) A negative attack after which the defending team had ideal conditions for setting up an attacking combination involving four attacking players

(=) An attack immediately followed by a point for the defending team – the attacking player's error or blocking the attack.

The monitored variables were recorded by means of Data Volley 4 software (Data Project Sport Software, Bologna, Italy). The observer was a professional SVF analyst with many years of experience using Data Volley software. After 4 weeks, the same analyst repeatedly evaluated the quality of randomly selected attacks after a positive or a negative serve-reception in each age category. The score reliability was assessed using weighted Cohen's Kappa correlation coefficients, with results ranging from 0.84 to 0.89, indicating a high agreement (Altman, 1991).

*Statistical analysis*

We used the Chi-Square Test to find associations between the accuracy of serve-reception and the quality of the attack. We used the C contingency coefficient to determine the closeness of the relationship. To look for differences between the attack after a positive and a negative serve-reception at individual qualitative levels, we used the test of significance of differences of two relative values (Z-test). The results were evaluated at a 5% statistical significance level. All data analysis was performed through the SPSS statistical package (Statistical Package for Social Sciences, version 20.0) and MS Office, Excel 2010.

**Result**

After the overall analysis of the comparison of the quantitative and qualitative characteristics of the attack, we can conclude that the senior women attacked the most effectively. In the younger categories, the incidence of excellent attacks was much lower, with minimal differences between the categories. On the other side, the U20 players made the most errors and, surprisingly, the U18 players made the fewest errors (Table 3). As regards serve-receive accuracy, in the factual-logical analysis we have to take into account the game situations, in which the players in each category attacked the most often. In our study we found that after an accurate serve-reception, the seniors attacked the most often, and they were able to capitalize on this advantage with the highest incidence of excellent attacks. The fewest favourable game situations after the opponent's serve were in the U20 category (Table 2). Positive serve-reception prevailed in all categories. However, significant differences were found in all the studied categories ( $p < 0.05$ ).

**Table 2 Relative frequency of positive and negative serve reception in individual age categories**

Quality levels	U 18	U 20	Senior women
Positive serve-reception (%)	63.1	52.4	68.0
Negative serve-reception (%)	36.9	47.6	32.0
	Z = 9.0569, p<0.05*	Z = 2.0046, p<0.05*	Z = 11.2672, p<0.05*

\*  $p < 0.05$

When investigating the association between the serve-reception accuracy and the quality of the attack stroke, we found a statistically significant relation ( $p < 0.05$ ) in all the studied age categories (U18  $\chi^2 = 38.6463$ ,  $C = 0.1211$ ; U 20  $\chi^2 = 13.0766$ ,  $C = 0.1458$ ; senior women  $\chi^2 = 62.5291$ ,  $C = 0.3069$ ).

The statistical analysis results confirmed the assumption of a higher proportion of excellent attack (#) after a positive serve-reception in all the studied categories compared to an attack after a negative serve-reception (Table 4). Statistically significant ( $p < 0.05$ ) differences were also found in most other stages of the attack quality assessment, except for erroneous attacks (=), where we found no significant differences in attack after either a positive or a negative serve-reception in all the studied categories ( $p > 0.05$ ). Statistically insignificant differences were found for positive attacks (+) in the U20 and U18 categories ( $p > 0.05$ ). Table 3 shows that after a positive serve-reception, seniors had the highest attack excellence (#) especially compared to the U18 category. We saw a very similar incidence of excellent attacks in all categories after a negative serve-reception. Attacks, which we rate as positive (+), creating disadvantageous game situations for the defending opposing team, occurred most frequently after a positive serve-reception among senior female players compared to a similar relative frequency among the U20 and U18 players. After a negative serve-reception we can observe more significant differences in the individual categories: while U20 players had the most positive attacks, U18 players had significantly less, and senior women had the lowest occurrence of positive attacks, even lower than after a positive serve-reception. After a positive serve-reception, negative attacks (-) occurred at a decreasing frequency in terms of age, while the occurrence was significantly more frequent among the U18 players than among the senior females and U20 players. After a negative serve-reception, we found significant differences within each category, while the highest incidence was among senior women and the lowest incidence was in the U20 category. In the second key stage of the attack quality assessment, after which the attacking team makes an error and the opponent scores a point (=), we recorded the lowest number of errors after a positive serve-reception among the U18 players. In the case of attacks after a negative serve-reception, we observed a higher error rate among the U20 and U18 categories compared to an erroneous attack after an accurate serve-reception, with a more significant difference in the U18 category. In the women's category, the attack error rate was without any significant differences.

The contingency coefficient for females reaches 45% of the possible coefficient for the given contingency table ( $C_{max} = 0.86602$ ), 27% for U20 and 19% for U18. These results suggest a decreasing closeness

of the relationship between the serve-reception accuracy and the qualitative characteristics of the subsequent attacking stroke from the oldest age category to the youngest one, thus confirming our hypothesis.

**Table 3 Frequency of attack following a positive and negative serve-reception in individual age categories**

U 18									
$\chi^2 = 38.6463,$									
$C=0.1211, p<0.05^*$									
	(=)			(-)		(+) )		#)	
	N	n	%	n	%	n	%	n	%
Attack – total	<b>601</b>	<b>78</b>	<b>13.0</b>	<b>186</b>	<b>30.9</b>	<b>117</b>	<b>19.5</b>	<b>220</b>	<b>36.6</b>
Attack after a positive reception	379	44	11.6	102	26.9	77	20.3	156	41.2
Attack after a negative reception	222	34	15.3	84	37.8	40	18.1	64	28.8

  

U 20									
$\chi^2 = 13.0766, C=0.1458, p<0.05^*$									
	(=)			(-)		(+) )		#)	
	N	n	%	n	%	n	%	n	%
Attack – total	<b>878</b>	<b>151</b>	<b>17.2</b>	<b>193</b>	<b>21.9</b>	<b>210</b>	<b>23.9</b>	<b>324</b>	<b>36.9</b>
Attack after a positive reception	460	74	16.1	76	16.5	98	21.3	212	46.1
Attack after a negative reception	418	77	18.4	117	28.0	112	26.8	112	26.8

  

Senior									
$\chi^2 = 62.5291, C=0.3069, p<0.05^*$									
	(=)			(-)		(+) )		#)	
	N	n	%	n	%	n	%	n	%
Attack – total	<b>488</b>	<b>69</b>	<b>14.1</b>	<b>119</b>	<b>24.4</b>	<b>98</b>	<b>20.1</b>	<b>202</b>	<b>41.4</b>
Attack after a positive reception	332	47	14.2	47	14.2	80	20.3	158	47.6
Attack after a negative reception	156	22	14.1	72	46.2	18	18.2	44	28.2

**Table 4 Significance of differences in the quality of the attack after a positive and negative serve-reception in individual age groups**

Quality levels	U 18	U 20	senior women
Excellent Attack (#)	Z = 3.029, p<0.05*	Z = 5.9167, p<0.05*	Z = 4.0547, p<0.05*
Positive Attack (+)	Z = 0.6869, p>0.05	Z = -1.9045, p>0.05	Z = 3.2293, p<0.05*
Negative attack (-)	Z = -2.7962, p<0.05*	Z = -4.0983, p<0.05*	Z = -7.6766, p<0.05*
Attack error (=)	Z = -1.3047, p>0.05	Z = -0.9153, p>0.05	Z = 0.016, p>0.05

**Discussions**

We found that the accuracy of the serve-serve significantly influences the qualitative characteristics of the attack across all the age categories. Thus, we confirmed the findings of several studies looking for links between prior and subsequent play activities in the playing chain (Monteiro et al. 2009, Paulo et al. 2016, Conti et al. 2018, Zapletalová, Mašek 2011). This is despite the fact that these two game activities do not follow each other, and the game activity between them – passing – can partially correct the accuracy of the serve-serve in both a positive or a negative way. In terms of the stability of game actions under difficult match conditions, our hypothesis was that the accuracy of serve-reception would influence the qualitative characteristics of the attack the most in the women's category and the least in the U18 category. We assumed that younger players with less playing experience and lower somatic and motor parameters (see Table 1) would not be able to take advantage of the precision of serve-reception to the same extent.

The decreasing closeness of the relationship between serve-reception accuracy and attack efficiency from the senior female category to the U18 category was confirmed by our research. Similar findings are

reported by Zapletalová and Mašek (2011). We also found minor differences in internal relations; however, the interpretation there of is not straightforward. As expected, internal relations, especially, in the category of senior women are based on practical experience. Overall, the senior women attacked more often after a positive serve-reception than the U20 and U18. These results corroborate the findings of Paulo et al (2018) in the male category that with increasing age the efficiency of serve-reception improves but, in terms of gender, males have more accurate serve-reception compared to females (Palao et al 2009). The seniors were able to take advantage of the high number of favourable match situations to start excellent attack the most often. After a negative serve-reception, the teams scored fewer points with attack, which resulted from more unfavourable match situations for setting up a quick combination attack with the possibility of involving the attackers in the middle of the net and, on the other side, creating more space to form a defence. Players in the senior category did not take unnecessary risks after a negative serve-reception and rather attacked in an effort not to make an error and relied on the subsequent defence and possible counter attack. Similar tendencies were found in both younger age groups; however, their attack efficiency did not reach the same level as the senior women, especially after a positive serve reception. As we have already mentioned, this is probably due to the higher possibility of attacking after a positive serve-reception, lower intensity, due to stability and variability of the attacking technique, and also tactical maturity and related experience. The relatively low error rate in attack in the U20 but especially U18 categories is somewhat surprising. The reason may be the tactics of the attack based on the strategy aimed to minimize their own errors, which girls in youth categories can already follow. The very small differences in the statistical characteristics of the teams' attack performance after receiving a serve in the U20 and U18 categories are explained by the small difference in their calendar age and thus probably also by similar playing experience or small differences in the somatic and motor parameters (Table 1). We would probably find more significant differences in the case of bigger age differences with, for example, a comparison with the U16 category.

Overall, the results indicated the importance of the accuracy of serve-reception for the subsequent effectiveness of the attack in all the studied age categories and the similarity in the qualitative indicators of the attack after positive and negative serve-reception. However, in the case of a direct confrontation, the dominance of the senior women would most likely be confirmed as, unlike in the youth categories, their game is of a more dynamic nature. In our case, it is mainly about higher variability and intensity of the attack, faster and more surprising passing. Senior players are more likely to play offensively after an accurate serve-reception, which could be even more common after serves by younger players. In addition to the accuracy of the pass, the success in attack is definitely related to the opponent's actions. It means the quality of the block and defence in the field. Here we also assume that high-level teams have more sophisticated blocking tactics, height and spike, they can block very fast attacks by the opponent, and their ball control is at a higher level.

### Conclusions

The scientific contribution of the study involves the analysis of the relation between the accuracy of serve-reception and the subsequent quality of the performance of the attack. The paper again confirmed the importance of serve-reception accuracy for the subsequent attack. Our work was unique because the research was carried out in as many as three age categories. According to our assumptions, we found that the examined relation is the closest in the senior women's category and decreases with age. However, from a substantive-logical point of view, the relative frequency of the occurrence of individual stages of attack assessment following a positive and negative serve-reception is similar in all the age categories studied. The results can be useful in evaluating the performance of female players in matches and serve as model characteristics of the team's game in side-out transition in the age categories studied. Verification of findings in male categories or other age and performance categories requires specific follow-up research.

**Conflicts of interest** – There is no conflict of interest

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