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**Research Article**

# ANALYSIS OF BEACH VOLLEYBALL ACTION SEQUENCES OF FEMALE TOP ATHLETES

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## ABSTRACT

The purpose of the study was to investigate sequences of typical beach volleyball actions to determine action patterns and anticipate athlete's behaviour. Videos from 18 games including 1645 action sequences consisting of 10918 actions from female World Tour athletes were analyzed. Single actions were recorded in a data base and probabilities of serve-reception, set-attacking, and reception-attacking action sequences were determined by means of data base queries. Chi-square tests were applied to determine significant patterns. Results did not reveal any superior type of serve which would create difficulties for the receiving team ($p>0.05$). The type of attack (smash or shot) did not significantly depend on the position of the setting. However, there was a tendency ($p=0.054$) to hard attacks when the ball was preceded by a setting far away from the net of from a lateral position near the side lines. The temporal position within a rally did neither effect the type nor the quality of attack ($p>0.05$). Contrariwise, the quality of the preceding reception did influence the type ($p<0.01$) and the quality ($p<0.05$) of attack. Following "good" receptions athletes preferred hard attacks and were more effective compared to situation where they had "perfect" or "poor" receptions. Although dependencies could not be detected in all analyzed cases the analysis of beach volleyball action sequences even by simple means of probabilities is a promising method to determine tactical patterns in beach volleyball.

***Key words:*** *notational analysis, interaction, performance, probability.*

***Reference Data:*** Koch C, Tilp M. Analysis of beach volleyball action sequences of female top athletes. *J. Hum. Sport Exerc.* 2009; 4(3):272-283.

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## INTRODUCTION

Game analysis in sport games has become increasingly important for practitioners during the last years. Professional sport clubs spend a significant amount of money in analyzing opponents for match preparation. Most approaches to systematic analysis of sport games rely on notational data (Hughes & Franks, 2004) often related to video systems. In general, single actions are assessed and mapped to action variables to represent the most important aspects of the game. The result of such analyses is a distribution of actions which may give valuable information about strengths and shortcomings of athletes or teams. A specific weakness of such an approach is that it does not consider the player's (or opponent's) prior actions which may influence the observed action.

Therefore, in recent years scientists began to concentrate their studies on the sequences of actions, transitions between situations, and the alternating interactions between teams and players. The aim of such approaches is to model sequences of actions to gain a deeper insight into the tactical behaviour of teams. The main approaches are: (I) the investigation of sequences of actions by Markov chains (Eom, 1988; McGarry & Franks, 1994, 1995), (II) the modelling of perturbations and fluctuations during rallies with dynamical system theory (Jäger & Schöllhorn, 2007; Lames & Walter, 2006; McGarry, Anderson, Wallace, Hughes & Franks, 2002; McGarry, Khan & Franks, 1999; Pöhler, 2007; Reed & Hughes, 2006; Schöllhorn, 2003), and (III) the analysis of sequences or patterns of a game using artificial neural networks (Perl, 1997; Perl, 2002; Pfeiffer & Perl, 2006; Jäger, 2006; Jäger & Schöllhorn, 2007).

Since beach volleyball is a developing type of sport with ongoing changes of the rules (e.g. reduced court size, rally point system) it has been in the focus of game analysts. Giatsis (2003) observed a significant increase in game duration following the introduction of the rally point system. Regarding the court size change (from 9x9 to 8x8 m) Ronglan & Grydeland (2006) reported a decreased attack and service efficiency combined with an increased number of block actions and block efficiency of elite players (FIVB-World Tour). However, defence efficiency did not improve which was intended by the beach volleyball association. Conversely, on the Greek national level Giatsis & Tzetzis (2003) observed increased attack efficiency, less attack errors and a decreased reception quality due to the court size change.

By determining the distribution of actions scientist also investigated possible differences between men and women games as well as winning and loosing teams. Both, Laios (2008) and Koch & Tilp (2009) found out that the differences due to gender were only observed in the type of applied techniques but not in their quality. Giatsis & Zahariadis (2008) could observe that 2:0 winning teams on international level (FIVB) have superior skills in almost all techniques, especially in avoiding attack errors. During close games (2:1 wins) only the amount of points discriminated winners from losers. Michalopoulou, Papadimitriou, Lignos, Taxildaris & Antoniou (2005) identified the effectiveness of attack and serve as key predictors for winning teams on the Greek national level.

The reported papers on beach volleyball give valuable information for athletes and coaches. However, they still lack of potential to investigate sequences of actions which are essential in beach volleyball which is characterized by a rigid game structure (Figure 1). Every single action affects the following (chain of) actions and every action in

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complex 1 ( C1 or s ide out : attack pr eparation i ncluding t he first a ttack f ollowing a service) may affect actions in complex 2 (C2: first counter attack) and so on (see Figure 1).

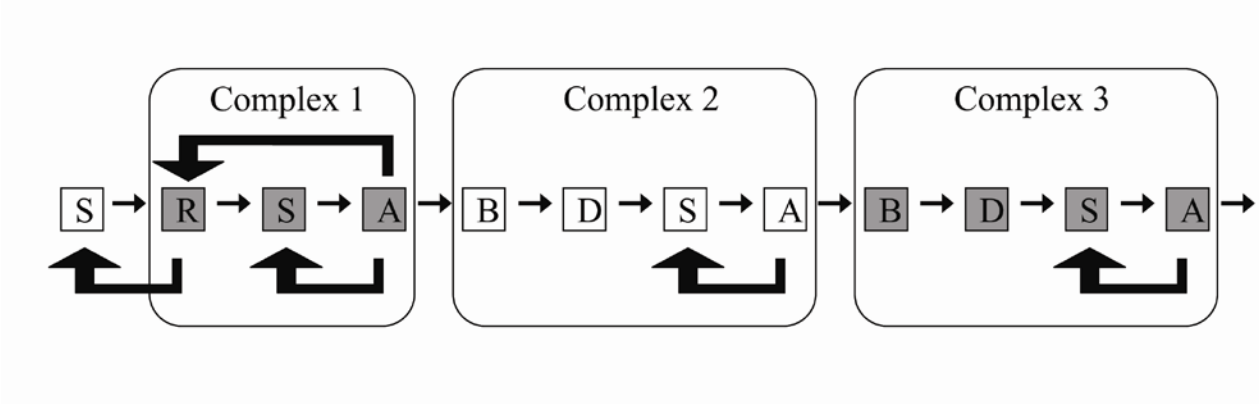


***Figure 1.*** *Visualization of a typical beach volleyball rally including all possible actions (Serve (S), Reception (R), Setting (S), Attack (A), Block (B), Defence (D)). The white and shadowed boxes represent actions of opposite teams. Each sequence of actions within one team is often defined as complex (C1, C2, and so on). Arrows represent the dependency of actions on preceding actions which were analyzed in this study.*

One impor tant a spect of inve stigating action sequences is the pos sibility to anticipate the behaviour of oppon ents. This is especially from great interest dur ing actions when teams are interacting, e.g. athletes and coaches want to know in which situations their opponents play hard (smash) or precise (shot) attacks. Therefore, the aim of this study was to investigate the relationship between actions within action sequences (rallies). By determining th e pr obabilities of specific action sequences we addressed the following questions which can not be answered by only assessing single actions:

- Which type of serve induces difficulties or errors of the receiving team?
- Which type of a ttack is f avoured following o ptimal s ettings f rom different positions?
- Does t he temporal position of an attack within a r ally (C1, C2, etc.) af fect the attacking technique and quality?
- How does the reception quality influence the following attack?

Specifically, we hypothesized

- that there is a most effective service technique,
- that the setting position affects the type of attack,
- that the reception quality may affect the type of attack,
- and that the temporal position of attacks within a rally (C1, C2 etc.) affects type and quality.

## METHODS

### *Sample*

Video material from the beach volleyball grand slam in Klagenfurt 2007 was available for t he ana lysis. 18 m atches of f emale el ite pl ayers w ere r ecorded. The cam era w as placed 17 meters behind the ba seline and 5 meters above the court. In t otal we

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categorised 10918 actions out of 1645 rallies, which were performed by 50 female athletes from 16 nations.

***Data analysis***

First, all single actions were categorised with a computerised notation system called "Statshot" and recorded in a database. For the six technical and tactical elements serve, reception, setting, attack, block and defence we assessed the applied technique, the quality of the action and the position on the court, represented by various zones (see Figure 2). Since position was an important attribute for assessing game actions a homography based software tool was used to determine court position with high accuracy (Mauthner, Koch, Tilp & Bischof, 2007; Koch, Mauthner, Tilp & Schrapf, 2009). Different from other categories the position of receptions was categorized relative to the player (front, back, left, right). A detailed description of the categories can be found in Tilp, Koch, Stifter & Ruppert (2006).

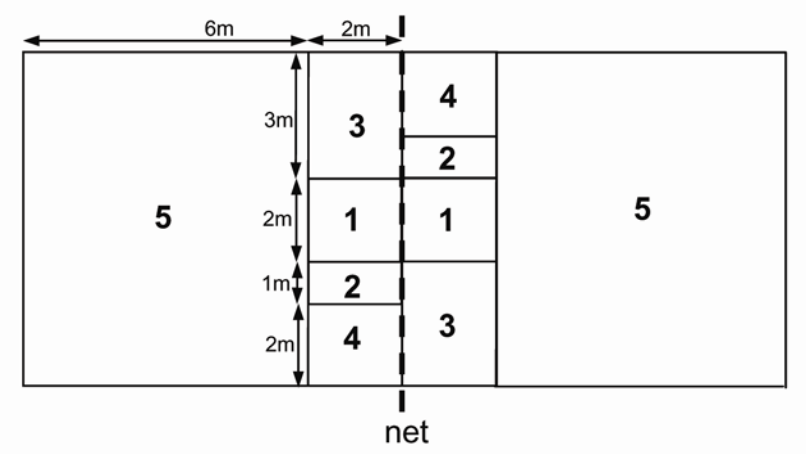


***Figure 2.*** *Definition of the five setting zones on the beach volleyball court.*

Quality was graded with a 4-point scale: (1) perfect; (2) good; (3) poor; and (4) mistake. When an action was a direct interaction with the opponent (e.g. serve or attack) the four grades describe the following situations: (1) direct point; (2) the action causes troubles for the opponent in the (counter) attack preparation (3) the opponent has no troubles in the attack preparation process (4) direct point for the opponent. When an action was an interaction with a team mate (e.g. reception, setting) it was rated as follows: (1) optimal conditions for the next action (regarding height, position and distance of the ball to the net); (2) not all criteria are optimal for the next action (for example: trajectory is too low); (3) the pass could only be reached with difficulties by the partner; (4) the pass could not be reached by the partner.

***Database queries***

Following the categorization process every single action was related to preceding and following actions during each rally. The recording in a data base allowed queries to determine probabilities of specific action sequences. Two or more elements of interest with specific characteristics (e.g. "jump serve" and "poor" reception") could be selected to calculate the probability of the selected action sequence in relation to the total number of rallies.

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Since a sub-optimal setting would reduce the range of opportunities for the attacking athlete regarding technique and quality we restricted the analyses to "perfect" settings. This guaranteed that in principal any type of attack could be performed by the attacking athlete. Long rallies (≥C3) are rare in beach volleyball and actions sequences in such complexes often lose their rigid structure. Therefore, for the analysis we collapsed all complexes ≥C3 into one group.

***Reliability***

The annotation and the assessment of the single actions were performed by experienced beach volleyball players. A detailed description of the reliability and objectivity tests can be found elsewhere ( Tilp et al., 2006 ). Briefly, the Scott's Pi coefficients for reliability and objectivity for a test sample of about 100 scenes were 0.93 and 0.90, respectively.

***Statistics***

Chi square tests were used to determine significance of action sequence patterns. The level of significance was set to p=0.05.

## RESULTS

*Which type of serve induces difficulties or errors of the receiving team?*

First, we related the service techniques to the amount of unusual or uncontrolled reception techniques (e.g. one handed, tomahawk) which indicate high pressure exerted by the serving team. Unusual reception techniques had to be performed following 4.7 % of the float serves, 5.4 % of the jump float serves, and 8.0 % of the jump serves. However, the influence of serve technique on the amount of unusual reception techniques was not significant (p=0.341).

Separately, we analyzed if there is a relationship between service techniques and reception quality ( figure 3). The quality categories "mistake" and "poor reception" as well as "no contact" ( direct aces) represent low reception quality. The greatest percentage of "poor receptions" (58 %) was observed following jump float serves but similar percentages were also observed following other service techniques ( see figure 3). Jump serves induced to the highest amount mistakes ( 8 %) while only 4 % of the receptions following float serve and jump float serve were performed negatively. Following both types of float serves 2 % of the balls could not be touched at all by the receiving team ( no contact). 1 % of the jump serves were direct aces. However, Chi square tests did not confirm a significant relationship between service technique and reception shortcomings (p=0.613).

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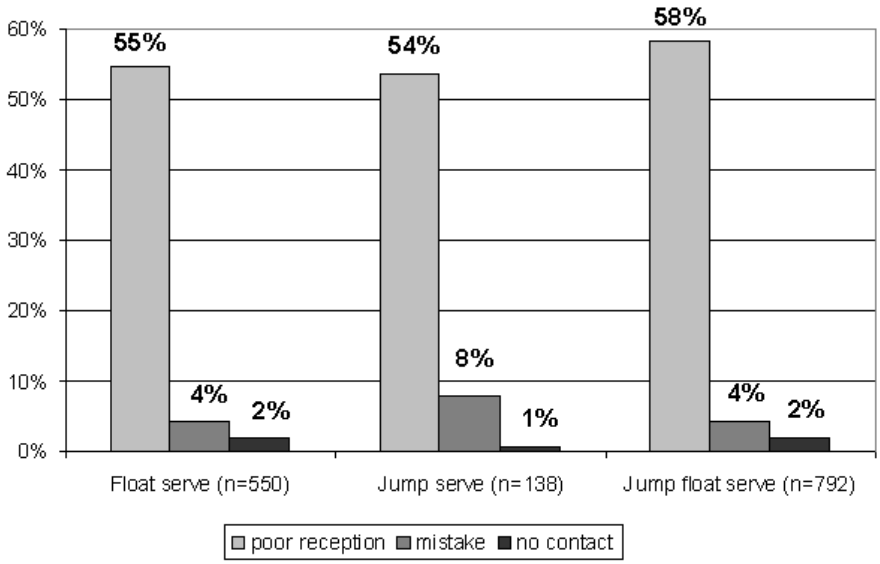


***Figure 3.*** *Distribution of reception quality in dependence of serving technique.*

*Which type of attack is favoured following optimal settings from different positions?*

The analysis of the favoured type of attack following optimal settings from the five different setting zones (figure 4) revealed that the percentage of smashes is higher when the preceding setting was performed from a lateral position (zone 3 and 4) or in the backcourt (zone 5). Between 56 % and 62 % smashes were played following perfect settings from these zones. Contrary, when the perfect setting came from the central part alongside the net, athletes used both techniques to the same extent (zone 1: 51 to 49%) or even preferred shots (55%) to smashes (45%) in zone 2. Although Chi-square test did not find a significance (p=0.054), the low p-value indicates a strong tendency towards a relationship between setting position and type of attack (figure 4).

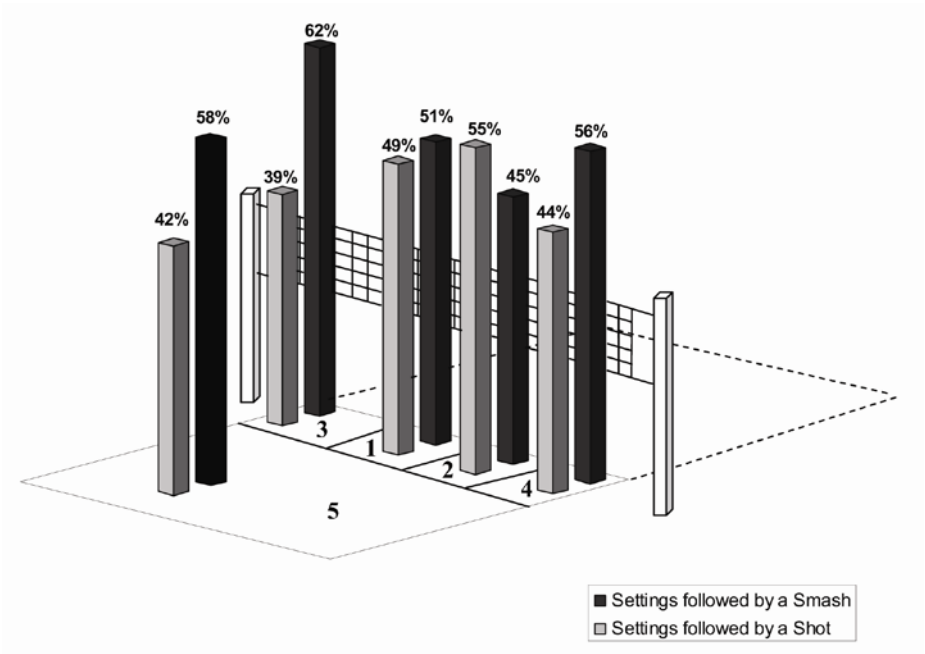


***Figure 4.*** *Percentage distribution of attack techniques following perfect set depending on the setting zone in C1 (Zone 1: n=342; Zone 2: n=74; Zone 3: n=78; Zone 4: n=32; Zone 5: n=467).*

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*Does the temporal position of attacks within a rally (C1, C2, etc.) affect the attacking technique?*

In each of the different playing complexes (C1, C2, and ≥C3) it was observed that athletes preferred smashes (55-59%) to shots (41-45%). The choice of attacking technique following a perfect setting (figure 5) did not depend (p=0.61) on the temporal position within a rally, i.e. if it was executed following a reception, or following one or more defence actions in C1, C2 or ≥C3, respectively.

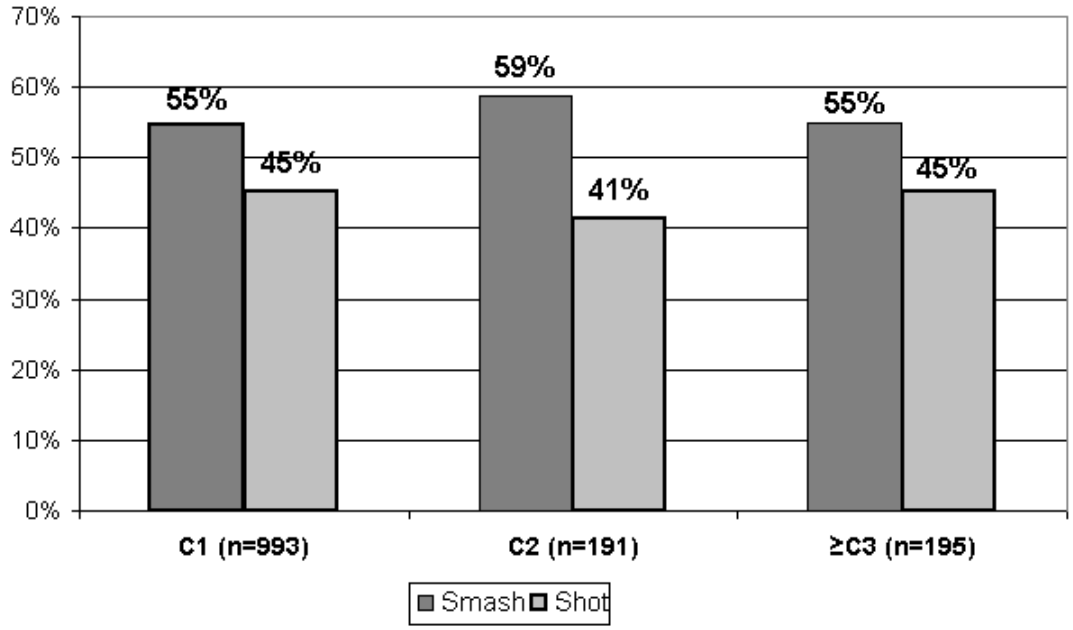


***Figure 5.*** *Percentage distribution of attack techniques following perfect sets related to different complexes (C1, C2 or ≥C3).*

*Does the temporal position of attacks within a rally (C1, C2, etc.) affect the attacking quality?*

Athletes were always able to score more than 50 % direct points with their attack. Although the best attacking rate was observed in C2 (65%, see figure 6) the overall attacking quality distribution was independent of the complex during which the attack executed (p=0.08).

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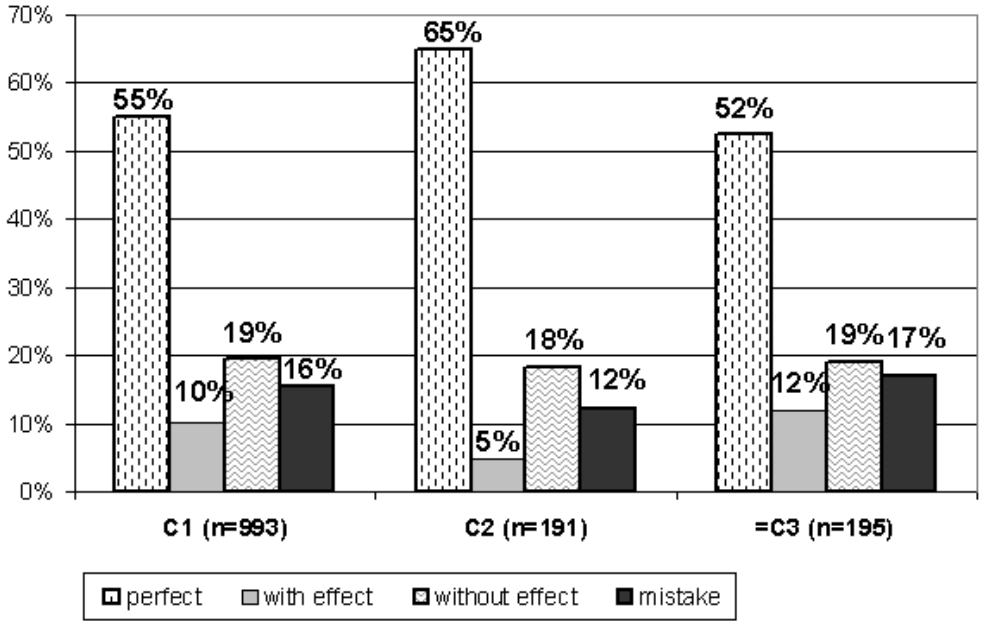


***Figure 6.*** *Percentage distribution of attack quality following perfect settings depending on different C-Situations.*

*How does the reception quality influence the following attack?*

Analysis revealed that the quality of the reception affects the choice of attacking technique in complex C1 ($p<0.01$). The analyzed players preferred shots (55%) to smashes (45%) only following "perfect" receptions. Both following "good" and "poor" receptions female beach volleyball players preferred hard attacks (figure 7).

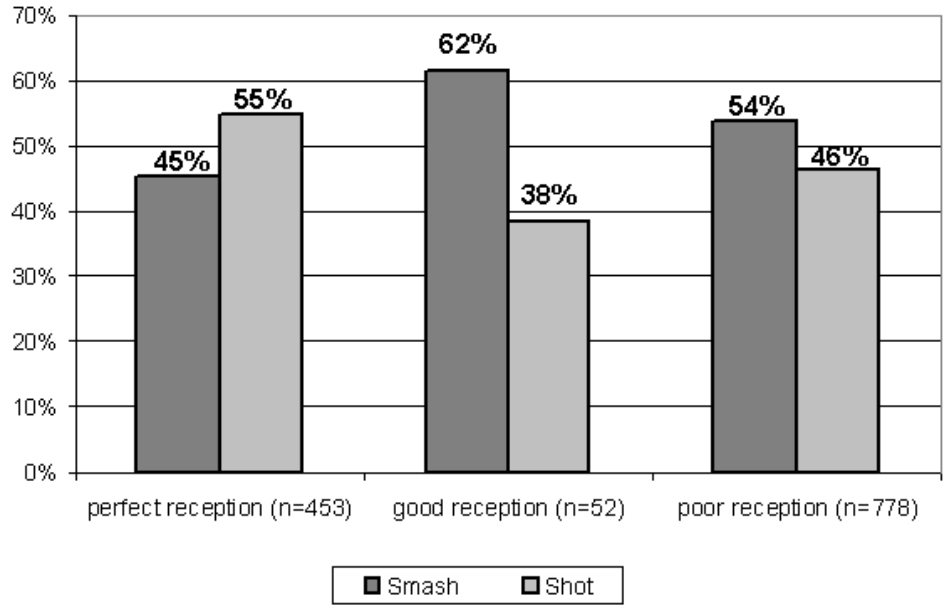


***Figure 7.*** *Percentage distribution of attack techniques following different reception qualities in C1. Attacking technique was dependent on reception quality ($p<0.01$).*

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Reception quality affected the attacking quality significantly ($p<0.05$). The highest success rate was achieved following good receptions (63%) and the lowest following "poor" receptions (47%). Furthermore, the highest amount of attacks "without an effect" or "mistakes" (together 43%) was observed following "poor" receptions (figure 8).

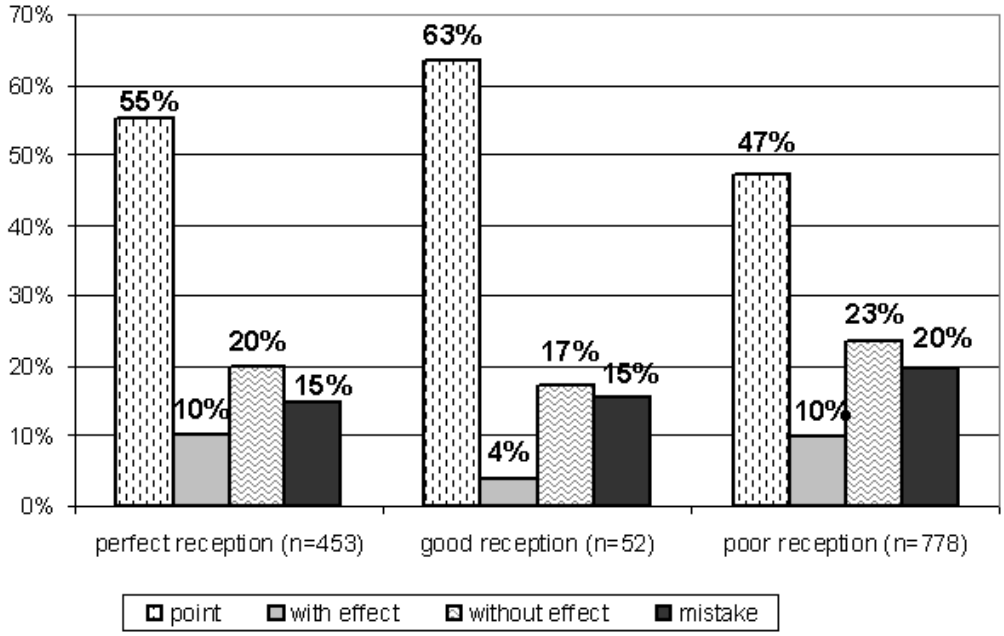


***Figure 8.*** *Percentage distribution of attack quality following different reception qualities in C1. Attacking quality was dependent on reception quality ($p<0.05$).*

## DISCUSSION AND CONCLUSIONS

The aim of this study was to analyze actions in beach volleyball in context to preceding actions by opponents, team mates, or by the athlete itself. This approach is different from previous analyses in beach volleyball (e.g. Giatsis, 2003; Ronglan & Grydeland, 2006; Laios, 2008; Koch & Tilp, 2009) where single actions were analyzed to e.g. discriminate winning from loosing teams or analyze gender differences in beach volleyball. Therefore, to the best knowledge of the authors, the presented results are novel to the literature. The analysis of action sequences is a promising analysis method since it may contribute to anticipate opponent's behaviour. For beach volleyball athletes and coaches it is from particular interest to know which type of serves create difficulties for the receiving team (serve – reception relationship) or which type of attack (smash or shot) will be executed following a specific actions (set – attack relationship).

Contrary to our hypothesis there was no significantly superior service technique detected. The results indicate that the different service techniques (jump serve, float serve, and jump float serve) create difficulties or errors of the receiving team to a similar extent. Similarly, the analysis of the relationship between setting position and type of attack did not show significant differences although a tendency could be observed ($p=0.054$). It might be speculated that athletes take more risk and therefore

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play hard attacks if the ball was set far from the net or from a lateral position which both makes the attacking situation more difficult.

More than half of the first attacks during a rally (C1) lead to a direct point (55%, see figure 6). The receiving team is therefore under compulsion to win the rally. Contrary, it is a good opportunity for the serving team to score the point if it gets the chance to perform a counter attack. Therefore, we hypothesized that attacking technique and quality varies depending on the temporal position within a rally. However, the analyzed data did not indicate a strong relationship between temporal position and attacking technique. The highest attack efficiency was observed in complex C2 (counter attack) where 65 % of the attacks lead to direct points. Attack quality in C2 was not significantly different ($p=0.08$) from C1 and ≥C3 situations. However, we might speculate that the moderately increased efficiency in C2 might be due to the easier standard defence situation following an attack in C1 and because it gets more difficult to prepare a structured attack in ≥C3. It should further be noted that during C2 the least attacking errors were observed (figure 6).

Furthermore, the analyses revealed a relationship between the quality of the reception and the type ($p<0.01$) and quality ($p<0.05$) of attack, respectively. Athletes preferred smashes and their attacks were more effective when the preceding reception was "good" compared to "perfect" or "poor" receptions. The decreased rate of smashes and direct points might be explained by more difficult attacking conditions following "poor" reception. However, the authors fail to explain the surprising observations following "perfect" receptions.

Although the presented analysis revealed promising results regarding the relationships during action sequences observed in the female world class beach volleyball population it would be from even greater value to analyze action sequences of single teams or single players against different opponents. To anticipate opponent's behaviour a considerable amount of preceding games of a team has to be analyzed which was not possible during a single tournament and definitely restricts the value of this study. However, the results represent the general behaviour in women world class beach volleyball.

A further constraint of the study is that the results depend on the specific category system established together with international beach volleyball coaches (Tilp, Koch, Stifter & Ruppert, 2006). During the video analysis it appeared that some teams may deliberately use techniques which are not rated "perfect" or even "good". This could explain the rather small amount of "good" compared to "poor" receptions and might have influenced the results.

Although the analysis of action sequences may give valuable information to anticipate the opponent's actions, it still generates only probabilities and it will never be possible to predict human behaviour with absolute certainty. Especially, excellent athletes show amazing creativity to find optimal solutions in a game situation without any connection to preceding actions or games (McGarry & Franks, 1994). However, Jäger & Schöllhorn (2007) could identify team specific patterns and selected offensive and defensive strategies even in volleyball national teams. We speculate that the value of action predictions based on notational (action sequence) analysis depends on the

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performance level of the analyzed sample. Further research dedicated to the predictive value depending on the performance level should be done in the near future.

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