GROSS MOVEMENT PATTERNS IN ELITE FEMALE BEACH VOLLEYBALL

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Preliminary communication
UDC 796.325.553:796.054-055.2

Abstract:

Recent research has shown the developments made in the analysis of gross movement patterns in tennis, but such research has yet to be extended to the field of beach volleyball. This study was designed to develop a method for analysing gross movement patterns so as to quantify movement types and their relationship to real competition and performed during the European Beach Volleyball Championships held in Valencia (Spain) in 2006, using the SportsCode analysis software. The aim of the study was to compare gross movement types and patterns in female professional beach volleyball. A quantitative analysis of beach volleyball play was carried out on 10 players taking part in the aforementioned volleyball championship, using video recordings of the 1,646 movements that were registered in four matches played. The recordings were analysed using SPSS ver. 13.0. Chi-square tests showed significant differences between the types of gross moves. The first result of the analysis showed that female players used the *offensive movement patterns* (OMPs) 59% of the time ($p \leq .001$), and the *defensive movement patterns* (DMPs) 41% of the time. The second result showed that 24% of the DMPs were *receptions*, 29% ($p \leq .05$) were *blocks*, and 47% ($p \leq .001$) were *defence moves*. The final analysis showed that 34% ($p \leq .001$) of the OMPs were *placements*, 50% ($p \leq .001$) were *attacking moves*, and 16% were *attack preparation moves*. Identifying and understanding DMPs and OMPs in female top-level players is vital for defining specific and effective beach volleyball training strategies.

Key words: *defensive movement patterns, beach volleyball, analysis, female, offensive movement patterns*

Introduction

Gross movement patterns in competitive sport have often been analysed to shape optimal training sessions in numerous sports. Only the work of Hughes and Meyers (2005) attempts to link movement patterns to rally outcomes and sequences of these patterns to obtain a much more relevant picture of what exactly happens in the game. However, beach volleyball lacks research of this kind. The purpose of this study was to develop a comprehensive and efficient system for comparing the defensive movement patterns (DMPs) and the offensive movement patterns (OMPs) performed by female beach volleyball players.

The introduction of the current scoring system, with two 21-point sets without needing to have the service to score, a possible 15-point third set and the possibility of asking for time-outs (Penigaud, 2003), has led to clearly significant changes in the physiological (McErlean, Cassidy, & O'Donoghue, 2000), technical and tactical demands of the sport. However, scientific research into beach volleyball is scarce, and we therefore have to rely on competitive movement analyses carried out for other sports, like rugby (Docherty, Wenger, & Neary, 1988), handball (Schorer, Baker, Fath, & Jaitner, 2007), hockey (Sunderland, Bussell, Atkinson, Alltre, & Kates, 2006), basketball (Matthew, & Delextrat, 2009), soccer (Lago-Peñas, Rey, Lago-Ballesteros, Casais, & Domínguez, 2009), squash (McGarry, 2006), or tennis (Loffing, Hagemann, & Strauss, 2009). Recent studies of other sports, such as tennis, can to a certain extent be useful to identify movement patterns in beach volleyball as well, but more sport-specific information are neded to improve training and performance quality.

Furthermore, different methods using modern technical equipment like software, video recordings and subsequent computer analysis, have been used in other sports to document movement activity, and this can have an effect on the accuracy of the results. Specific documentation on the average

gross movement pattern data collected could provide valuable information on the total physiological demands of competitive beach volleyball.

However, few studies have investigated the use of technical features and tactics in beach volleyball. The most interesting is the one by Koch and Tilp (2009a) presenting comparisons between men and women, and the most common action sequences used by female players. The objective of our study was to compare gross movement patterns and types of motions in professional women's beach volleyball.

Methods

Participants

Ten female players (28±3.05 years of age, 1.75±.06 metres tall, body mass index 22.2±1.9, muscle mass 36.4±1%, fat mass 12.9±2.8% and body weight 65.5±5.23 kg) were filmed playing 9 sets spread over 4 matches during the 2006 European Beach Volleyball Championships. The participants in the study were members of their respective national female teams, and had similar characteristics to those described by Palao, Gutierrez, and Frideres (2008).

The sample included matches of the main draw for the women, meaning that all the teams had passed the preliminary round of the tournament.

Data acquisition

Two video cameras (one Sony DCR-VX2100E and one Sony TRV738E) were trained on the playing surface, the first facing across the court from a grandstand approximately 15 metres above the action, and the second facing down the court, approximately 10 metres from the court and parallel to the baseline (Figure 1). Both cameras were calibrated using four markers placed to create a reference framework that contained a 30% overlap over the boundaries of the court to allow action to be filmed even when the ball left the limits of the court. The movement patterns performed by the players during the matches and the duration of each point rally were recorded by both video cameras, which were equipped with time counters calibrated in minutes, seconds and tenths of a second.

Procedure and variables

Video recordings were made of the total of 1,646 gross movements that were performed in the four matches played. Each movement and time record was captured by the video cameras, using the parameters of the whistle blown by the referee to allow players to serve the ball and the whistle used to signal the end of the point play (Tilp, Koch, Stifter, & Ruppert, 2006).

A recording matrix was constructed using the following coordinates (Table 1 and 2): *the defensive movement patterns* (DMPs), a variable that appeared when the players performed either a *reception* (R), *block* (B), or *defence move* (D); the *offensive movement patterns* (OMPs); that is, either *placement* (C), *attack approach* (T), or *attack* (A). The coordinates between the types, that is, the direction of locomotion, of gross movement patterns were reconstructed using a dimensional recording matrix (Liebermann, et al., 2002).

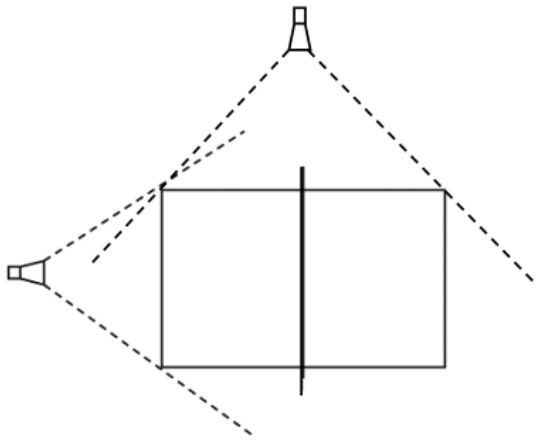

Figure 1. Diagram of the cameras' placement (an overhead view).

Table 1. Operational movement definitions

Defensive movement patterns (DMPs)	
Operation	*Definition*
Reception	any movement used by players to receive the ball directly from a serve
Block	a move performed at the net to prevent the ball from passing into one's court
Defence	any move performed to save the ball in a clear attack by the opposing team and deny the opponent from winning a point
Offensive movement patterns (OMPs)	
Placement	a move to prepare an attack by a player's team-mate
Approach to attack	an adjustment move for a possible attack
Attack	any move from a series of them aiming at placing the ball in the opponent's court and winning a point

The gross movement patterns were defined with the volleyball technical elements receptions, blocks, and defences (DMP - actions of defence), whereas the offensive movement patterns (OMP) consisted of: placement, attack approach, and attack, as actions of offence.

The movement patterns were quantified when players carried out a particular movement pattern (i.e. established a contact with the ball). This was clearly differentiated from the jump motor patterns or the attempted, but unsuccessfully performed defensive or offensive movement patterns (especially reception and defence move)[1].

The different *types of movement patterns* (direction of locomotion) were described in reference to the net (Figure 2), as follows: *advance* (AN), *lateral step added* (LP), *lateral extension* (LE) and *post* (P). All the figures were calculated by two experienced researchers, who rewound each point played twice to avoid computer software timer errors. The equation

$$(\% \text{ of error} = 100 \times |A - B| / ((A + B) / 2)(1))$$

was used to determine percentage differences when calculating the reliability of the systems using data from the observation points A and B (Choi, O'Donoghue, & Hughes, 2007).

Table 2. Different gross movement types with regard to the net

Operation	Court position
Advance	Front court
Lateral step added	Horizontal one step added towards the net
Lateral extension	Horizontal movement towards the net
Post	Rear court

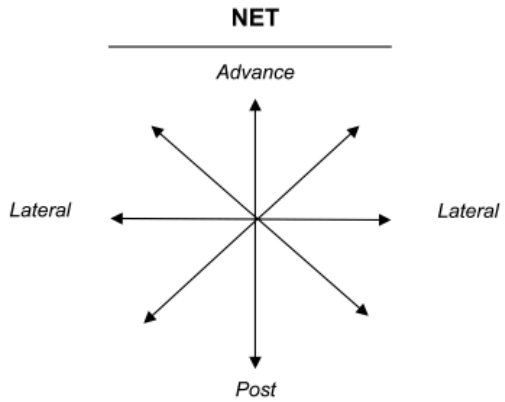

Figure 2. Directions of gross movements with regard to the net.

The research used different types of datasets, which required some form of data manipulation (Tables 3 and 4). This applied to the real-time system and the cycles data. The penalties data did not require any changes. For the purpose of the current investigation, a percentage of error of less than 5% was deemed to be acceptable (Nevill, Atkinson, Hughes, & Cooper, 2002).

By synchronizing the video cameras, time adjustment errors were avoided, as the analysis was performed using the two recordings at the same time. The observer reliability was also checked and cross-checked, together with the inter-observer and movement-type analysis (Williams, Hughes, O'Donoghue, & Davies, 2007). The SportsCode 2007 (GameBraker) software was used for the study, and the following stages were sequenced: A) recording and digitalization of the images; B) creation of a movement-type matrix; C) image capture for each matrix code; and D) combining the matrix codes to obtain gross movement performance in real beach volleyball competition.

Table 3. *Percentage differences for calculating reliability*

	AN				LP			
MP	Ob. 1	Ob. 2	Mean±SD	E %	Ob. 1	Ob. 2	Mean±SD	E %
R	38	39	38.5±.71	2.59	11	11	11±.0	.0
C	275	276	275.5±.71	.36	8	8	8±.0	.0
A	465	463	464±1.41	.43	1	1	1±.0	.0
B	83	83	83±.0	.0	86	84	85±1.41	2.35
T	94	92	93±1.41	2.15	14	14	14±.0	.0
D	66	68	67±1.41	2.98	62	62	62±.0	.0

Legend: movement pattern (MP), advance (AN), lateral step added (LP), reception (R), placement (C), attack (A), block (B), approach to attack (T), defence (D), Ob.=observer, SD=standard deviation, E=error

[1] Attempted moves were not registered, although the players moved across the court and tried to catch the ball. This affected the counting particularly of the defensive movement patterns and their ratio to the offensive movement patterns.

Table 4. Percentage differences for calculating reliability

	LE				P			
MP	Ob. 1	Ob. 2	Mean±SD	E %	Ob. 1	Ob. 2	Mean±SD	E %
R	82	84	83±1.41	2.41	17	17	17±.0	.0
C	15	15	15±.0	.0	35	35	35±.0	.0
A	15	15	15±.0	.0	0	0	0±.0	.0
B	34	34	34±.0	.0	0	0	0±.0	.0
T	13	13	13±.0	.0	31	31	31±.0	.0
D	62	62	62±.0	.0	130	128	129±1.41	1.55

Legend: movement pattern (MP), lateral extension (LE), post (P), reception (R), placement (C), attack (A), block (B), approach to attack (T), defence (D), Ob.=observer, SD=standard deviation, E=error

Data analysis

The data were analysed using SPSS v. 13 to calculate descriptive statistics, frequencies and distributions. The descriptive analysis is presented as the mean and standard deviation for quantitative variables. Chi-square (χ^2) tests were used to determine significance of qualitative data. The level of significance was set to $p \leq .05$ or to $p \leq .001$.

Results

The results of the analysis (Figure 3) showed that the observed beach volleyball female players used OMPs (attack, placement, approach to attack) in 964 ($p \leq .001$) of the moves, and DMPs (reception, defence and block) employed only 682 times.

Out of the total of 682 DMPs 160 were receptions, 202 were blocks and 320 were defence moves. The mean total of DMPs was 227.33±82.95, whereas out of the total of OMPs 480 were placements, 334 attacking moves and 151 were attack preparation movements. The mean total of OMPs was 321.66±104.84. Figures 4 and 5 show the percentage distribution of DMPs and OMPs.

Similarly, the different types of gross movement patterns that the players used: 1,021 advances, 181 lateral steps added, 232 lateral extensions and 212 posts. Figure 6 shows the percentage distribution of gross movement patterns. Table 5 shows the relationship between the defensive and offensive patterns of movements with the types of movements. The lateral movement extension was used more frequently than the other types of movements in reception. On the other hand, lateral-step added movement was the most used type of movement in block performance. The relationship between the direction of gross movement and offensive movement patterns emphasized the use of advance movements. Similarly, the advance movement is the most used in attack.

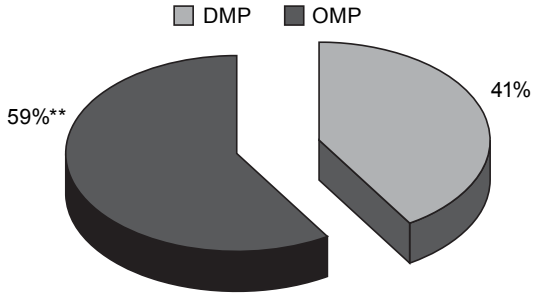

*Figure 3. Movement pattern percentages (N=1,646). Defensive movement patterns (DMPs). Offensive movement patterns (OMPs), **p≤.001.*

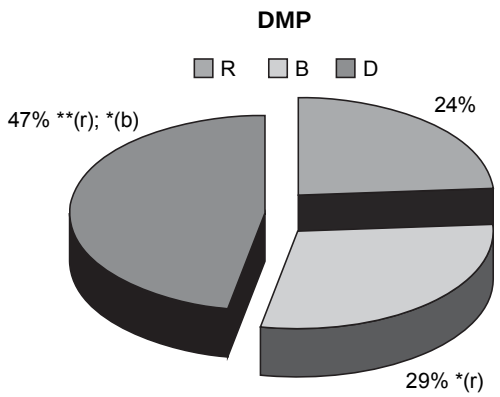

*Figure 4. Defensive movement pattern (DMP) percentages (N=682). Reception (R), defence (D), block (B), *p≤.05, **p≤.001.*

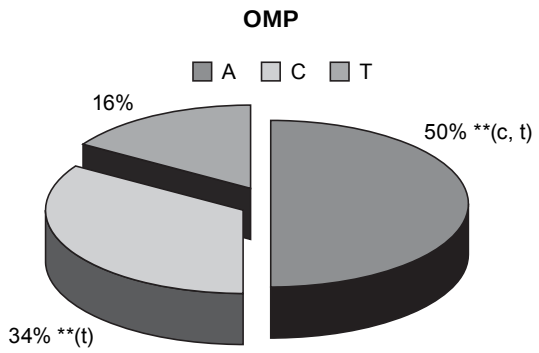

*Figure 5. Offensive movement pattern (OMP) percentages (N=964). Attack (A), placement (C), approach to attack (T), **p≤.001.*

Table 5. *Relationship between type of movement and movement patterns (%)*

		Type of movement			
		Advance (a)	Post (p)	Lateral step added (l)	Lateral extension (le)
Defensive movement patterns	Reception	24.4$^{**(l, le),*(p)}$	10.6$^{**(le),*(a)}$	6.9$^{**(l, le)}$	58.1$^{**(a, p, l)}$
	Block	41.1$^{**(p, le)}$	0$^{**(a, l, le)}$	42.1$^{**(p, le)}$	16.8$^{**(p, le, a)}$
	Defence	20.9$^{**(le)}$	49.7$^{**(a, l, le)}$	19.4$^{*(le), **(p)}$	10$^{**(a, p),*(le)}$
	Total	27.7$^{*(p)}$	21.4$^{*(a, le)}$	23.2	27.7$^{*(p)}$
Offensive movement patterns	Placement	84.1$^{**(p, l, le)}$	11$^{**(l),*(le)}$	.3$^{**(a, p, le)}$	4.6$^{**(a, l),*(le)}$
	Attack approach	61.6$^{**(p, l, le)}$	20.5$^{**(a),*(l, le)}$	9.3$^{**(a),*(p)}$	8.6$^{**(a),*(p)}$
	Attack	96.5$^{**(p, l, le)}$	0$^{**(a, l, le)}$	.2$^{**(a, l, le)}$	3.3$^{**(a, p, l)}$
	Total	86.3$^{**(p, l, le)}$	6.8$^{**(a, l),*(le)}$	2.4$^{**(a, p),*(le)}$	4.5$^{**(a)*(p, l)}$

* p≤.05, ** p≤.001.

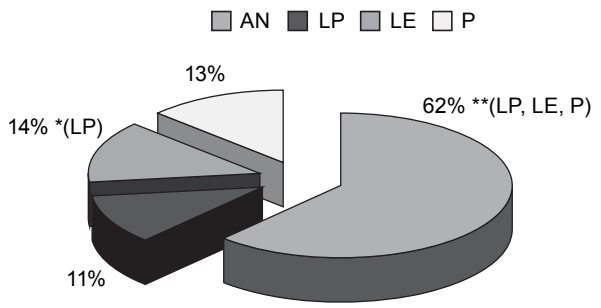

Figure 6. Different movement types used by players with regard to the net. Advance (AN), lateral step added (LP), lateral extension (LE), post (P), *p≤*.05,* **p≤*.001.*

Discussion and conclusion

During the 2006 European Beach Volleyball Championships (Valencia, Spain), players used different movement patterns (DMPs and OMPs) during the competition. Our results indicate that female players used different movement types in competition. The statistically significant difference was found in the offensive movement patterns used (59%; p≤.001), in comparison with the defensive movement patterns used (41%). The study showed how frequently certain types of movements were used, using the net as the reference point: 62% for advance (AN), 14% for lateral extension (LE), 13% for posterior (P) and 11% for lateral step added (LP), indicating the amount of training work that should be dedicated to each movement type (Tilman, Hass, Brunt, & Bennett, 2004). The relation between the patterns of the offensive and defensive movements with the type of movements is a key point in our research. This shows the connection between the reception actions and the lateral movement extension. It also shows the lateral-step added movement in the blocking action, and the movement advance in placements and attack. This analysis helps us to discover the physical work load in beach volleyball, and may help to prevent injuries. These results indicate a tendency to move vertically to the net.

The number of other types of movement should also be calculated, thus giving two variables to manage: types of movement and tactical determination (defensive and offensive). Of the defensive movement patterns used, 24% were receptions, 29% (p≤.05) were blocks, and 47% (p≤.001) were defence movements. Of the *offensive movement patterns* used, 34% (p≤.001) were placements, 50% (p≤.001) were attacking moves, and 16% were attack preparation movements. It is true that certain authors, such as Giatsis and Tzetzis (2003), as well as Grgantov, Katic, and Marelic (2005), believe that the current court size and the changes made to the scoring rules influence the use of movement time, and another study (Giatsis & Zahariadis, 2008) explores the differences in playing characteristics between winning and losing teams in the men's Beach Volleyball World Tour. Furthermore, in the study of different spike movements, players slowed their movements and changed the position of their feet with a difference in volleyball (Tilp, Wagner, & Müller, 2008). This new positioning of the feet can cause common beach volleyball injuries, such as quadriceps tendinosis and patellar tendinosis associated with knee pain (Pfirrmann, Jost, Pirkl, Aitzetmüller, & Lajtai, 2008).

However, although the results of this study may lead to a significant improvement in the preparation of training programmes for beach volleyball players, given the absence of any prior studies, we should be cautious and only extract the opportune conclusions. Beach volleyball training programmes should be based on the needs of the actual competition, emphasizing the use of movement types and tactical requirements.

The data show that elite female beach volleyball players produce sequences of different movements. Obviously, different movement patterns depend on what is required by the game being played. Chi-square test showed statistical significance in

the type of movement pattern used, in terms of defensive movement patterns in reception and blocks, and offensive movement patterns in placement and attack. The most significant difference in the use of sequences is advancing to the net followed by a combination of lateral movements. As for the differences between the movement patterns, the OMP is the most frequently used move (Koch & Tilp, 2009b). Improved understanding of the gross movement patterns and movement types is very important for establishing specific beach volleyball training drills and programmes. Also, it should lead to more investigations into players' physiological responses to competition, such as studying weight change and loss of fluids in official beach volleyball tournaments (Zetou, Giatisis, Mountaki, & Komninakidou, 2007).

The results of our investigation can be compared with those obtained by Koch and Tilp (2009b) on aspects of technique. Our work has similarities in the use of blocking movement patterns, using the technical movement for the impasse in the study (Koch & Tilp, 2009a), although it should be emphasized that our study was carried out on the gross movement patterns and not on technical elements performed. As a summary, we can state that the work by Koch and Tilp (2009a) is complementary to our study. The gross movement patterns should be taught in beach volleyball schools throughout the world. Although analysing movement patterns can provide valuable information to prepare players, training plans should be developed to improve the basic movement patterns used in beach volleyball. This means that once the gross movement patterns have been analysed and the gross movement types quantified, training methods can be designed based on actual competitive conditions, paying special attention to tactical actions with a limited number of repeated movements and intermittent rest periods, progressing to longer periods of this type of effort during matches.

In this study, due to the counting and registering criterion, we found that the patterns of offensive movements were more frequent in competitions than the defensive ones. Higher frequency was also obtained for the vertical advance types of movements with regard to the net area. This research is one of the first of its kind in beach volleyball, and has therefore raised several issues that must be addressed in subsequent research.

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Submitted: April 12, 2009
Accepted: December 10, 2009

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Acknowledgements

This research is a part of the project funded by the Ministry of Education, Social Policy and Sports, and the University of Alicante.

KRETNI OBRASCI VRHUNSKIH ODBOJKAŠICA NA PIJESKU

Novija istraživanja uspješnosti u sportu pokazuju velik napredak u analizi kretanja igrača u velikom broju sportova, no takva istraživanja tek valja proširiti i na odbojku na pijesku. Ovo je istraživanje oblikovano s ciljem da se razvije metoda za analizu kretnih obrazaca koja bi se sastojala u tome da se kvantificiraju kretne strukture i smjerovi kretanja u odnosu na mrežu. Istraživanje je provedeno na realnim natjecateljskim situacijama zabilježenima tijekom Europskog prvenstva u odbojci na pijesku, održanom 2006. godine u Valenciji (Španjolska). Korištena je programska podrška SportsCode za analizu kretanja. Cilj istraživanja bio je usporediti obrasce kretanja i vrste kretanja u odnosu na odbojkašku mrežu u vrhunskoj profesionalnoj ženskoj odbojci na pijesku. U kvantitativnoj je analizi sudjelovalo 10 igračica na uzorku od četiri utakmice spomenutog Europskog prvenstva. Video zapisom je je u ta četiri susreta zabilježeno ukupno 1.646 obrazaca kretnji. Video zapisi analizirani su programom za statističku obrau podataka SPSS, verzija 13. Hi-kvadrat testovima utvrđena je statistički značajna razlika među različitim vrstama kretnji. Rezultati analize pokazali su da odbojkašice na pijesku koriste napadačke kretne obrasce u 59% ($p \leq 0,001$) i obrambene kretne obrasce u 41% vremena igre. Također je utvrđeno da su 24% obrambenih kretnih obrazaca bili elementi primanja servisa, 29% ($p \leq 0,05$) elementi bloka i 47% ($p \leq 0,001$) elementi obrane. Analiza podataka pokazala je i da su 34% ($p \leq 0,001$) napadačkih kretnih obrazaca bili elementi dizanja, 50% ($p \leq 0,001$) napadačke kretnje i 16% priprema za napadačke kretnje. U Identificiranje i razumijevanje obrambenih i napadačkih kretnih obrazaca u ženskoj odbojci na pijesku ključno je za definiranje specifičnih i efikasnih trenažnih strategija u ovom sportu.

Ključne riječi: *kretni obrasci, odbojka na pijesku, analiza, žene*