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CURRENT GLOBAL TRENDS AND PROSPECTS FOR RESEARCH IN BEACH VOLLEYBALL: AN ANALYTICAL REVIEW OF THE SCIENTIFIC LITERATURE

СУЧАСНІ СВІТОВІ ТЕНДЕНЦІЇ ТА ПЕРСПЕКТИВИ ДОСЛІДЖЕНЬ У ПЛЯЖНОМУ ВОЛЕЙБОЛІ: АНАЛІТИЧНИЙ ОГЛЯД НАУКОВОЇ ЛІТЕРАТУРИ

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ABSTRACT

The presented article shows the relevance of studying a dynamic and popular sport – beach volleyball. Against the background of growing international competition, the scientific basis of the training process becomes the most important factor for achieving high sports results, especially for Ukraine, where this sport has a significant development potential.

*The **purpose** of the study is to identify and systematise the main directions and trends of modern scientific research in beach volleyball, as well as to determine the prospects for its development in Ukraine.*

*The research **methodology** is based on a set of theoretical methods of scientific literature analysis, including analysis of literary sources, systematisation, classification, interpretation, and generalisation.*

*The **results** of the analysis of scientific literature have revealed significant trends in beach volleyball research, in particular, the significant role of jumping, explosive power and speed in the competitive success of highly skilled players. A high level of skill is closely correlated with the effectiveness of offensive and defensive actions. Tactical interaction between players and their ability to adapt to changing situations are key success factors. In addition, individualisation of the training process and consideration of players' age characteristics are key aspects of training.*

***Conclusions.** Summarising the results of the analysis of 28 studies, the importance of specific physical training and the influence of the player's role on physical activity are emphasised. Because of the obtained results, practical recommendations for coaches, scientists, and sports organisations that train beach volleyball athletes in Ukraine are formulated.*

***Keywords:** beach volleyball, performance indicators, training methodologies, tactical adaptation, athlete development.*

Стаття розкриває актуальність дослідження динамічного та популярного виду спорту – пляжного волейболу. В умовах зростаючої міжнародної конкуренції наукове обґрунтування тренувального процесу стає найважливішим фактором досягнення високих спортивних результатів, особливо для України, де цей вид спорту має значний потенціал розвитку.

***Мета** дослідження полягає у виявленні та систематизації основних напрямків і тенденцій сучасних наукових досліджень з пляжного волейболу, а також визначенні перспектив його розвитку в Україні.*

***Методологія** дослідження ґрунтується на комплексі теоретичних методів аналізу наукової літератури, включаючи аналіз літературних джерел, систематизацію, класифікацію, інтерпретацію та узагальнення.*

***Результати** комплексного аналізу виявили важливі тенденції у дослідженнях з пляжного волейболу, зокрема значну роль стрибучості, вибухової сили та швидкості в досягненні змагального успіху висококваліфікованими гравцями. Високий рівень майстерності тісно корелює з ефективністю атакуючих і захисних дій. Тактична взаємодія між гравцями та їхня здатність адаптуватися до мінливих ігрових ситуацій є надзвичайно важливими факторами успіху. Крім того, індивідуалізація тренувального процесу та врахування вікових особливостей гравців є вирішальними аспектами підготовки.*

***Висновки.** Узагальнюючи результати аналізу 28 досліджень, підкреслено важливість спеціальної фізичної підготовки та врахування ігрового амплуа гравців стосовно фізичних навантажень. На основі отриманих результатів сформульовано практичні рекомендації для тренерів, науковців та спортивних організацій, що здійснюють підготовку спортсменів з пляжного волейболу в Україні.*

***Ключові слова:** пляжний волейбол, змагальна діяльність, тактична взаємодія, показники результативності, загальні тенденції.*

INTRODUCTION

Beach volleyball, like classical volleyball, originated in the United States of America, but its evolution is characterised by significant differences. While European countries focused on the development of traditional volleyball, the United States has seen a rapid development of beach volleyball since the 60s of the XX century, accompanied by the formation of unique rules, technical and tactical features. The sport peaked in popularity

in the mid-90s, when an increase in prize money, a growing number of tournaments and increased media attention contributed to the inclusion of beach volleyball in the Olympic Games programme in 1996.

The isolated development of beach volleyball at the initial stage contributed to the formation of its specific technical characteristics. Over time, leading European countries began to invest in the sport, which allowed them to improve their position in the international arena. Today, Brazil and the United States remain the leaders, but landlocked countries such as Austria and Germany also demonstrate a high level of development (Hunchenko et al., 2021).

In Ukraine, beach volleyball has a rich history and significant achievements (Hrynchenko et al., 2021). Domestic athletes, including Serhii Popov and Valerii Samodai, have won numerous awards at international competitions (FVU, 2016). The development of the sport is concentrated mainly in the southern regions, where climatic conditions are favourable for training, but also extends to the western regions. The Volleyball Federation of Ukraine coordinates the development of beach volleyball by organising competitions and creating infrastructure for the training of a sports reserve (Deviataieva, 2016).

Beach volleyball is characterised by significant differences from the classical one, in particular, by the number of players on the court and specific playing conditions. Successes in traditional volleyball do not guarantee high results in beach volleyball, as the latter requires versatility and a wide range of technical and tactical skills (Sopotnytska & Sopotnytskyi, 2022).

Competitive activity in beach volleyball is constantly evolving, which stimulates the search for new approaches to the training process (Plakhtyr, 2024). The analysis of the performance of technical and tactical elements of the game and statistical data allows to adjust the training process and increase the efficiency of the game. High requirements to physical fitness and psychological stability are key factors of success of teams in beach volleyball.

Thus, beach volleyball is showing dynamic evolution and has significant potential in Ukraine, which is confirmed by international achievements. Further development of this sport requires taking into account global trends and improving the training system.

METHODOLOGY

The research is based on the complex application of theoretical methods of scientific literature analysis in order to systematise and generalise certain knowledge of beach volleyball.

– *Analysis of literary sources*. The bibliographic search was carried out in the international scientometric databases Scopus, Web of Science, SPORTDiscus and PubMed. The key words of the search were 'beach volleyball', 'training', 'technical and tactical actions'. The literature was selected according to the following criteria: year of publication (preference was given to sources published in the last 10 years), type of source (scientific articles, monographs, conference materials), and thematic relevance. The initial search revealed 9438 publications, of which 62 were selected for in-depth analysis, and 28 of the most relevant sources were selected for detailed study.

– *Systematisation and classification*. The selected sources were systematised and classified into thematic blocks: the type of players studied (highly skilled, juniors, amateurs), the area of research (competitive activity, technical and tactical actions, physical training, psychological training, gender differences), research methodology (experimental, descriptive, analytical).

– *Interpretation and contextualisation*. The interpretation of the research results was carried out taking into account the specifics of the development of beach volleyball in Ukraine, in particular, the peculiarities of the national system of training athletes, climatic conditions and availability of infrastructure.

– *Method of analogies and generalisations*. In order to identify common patterns in the training of athletes, the method of analogies with related sports (classical volleyball, tennis, badminton) was applied. Based on the analysis of literature sources, effective training methods and factors influencing the results of players in beach volleyball were generalised.

Organisation of the study: the research was conducted in several stages:

1. Determining the purpose and objectives of the study. Based on the analysis of the current problems of beach volleyball development in Ukraine, the purpose and objectives of the study were formulated.
2. Search and selection of literature sources. A systematic search of scientific publications in international scientometric databases was carried out in accordance with certain criteria.
3. Analysis of the content of literary sources. A detailed analysis of the content of the selected publications was carried out in order to identify the main trends, patterns and problems in the field of beach volleyball.
4. Generalisation of results and formulation of conclusions. Based on the analysis of literature sources, general conclusions and recommendations for the development of beach volleyball in Ukraine were formulated.

RESULTS

– Analysis of the training of high-level international players

The review of scientific literature has revealed a significant interest of researchers in studying the aspects of training and competitive activity of highly qualified players in beach volleyball. The research covers a wide range of issues, including the analysis of technical and tactical actions, assessment of physical fitness, the influence of psychological factors and the use of modern data analysis technologies.

The aim of the study by Wenninger et al. (2019) was to identify the most common tactical combinations in elite beach volleyball. The study was conducted on the basis of a database containing information on more than 400 international matches played at FIVB tournaments during 2013-2016 among men's and women's teams. Each draw was considered as a sequence of preparatory actions describing the tactical combinations of players.

The results of the study demonstrated the effectiveness of data analysis methods (associative rules, clustering) for identifying tactical patterns in beach volleyball. Based on the analysis of more than 400 matches, gender differences in tactical schemes of the game and individual patterned interactions of players were identified. This allows to individualise the training process and improve tactical training. However, it should be noted that the study focuses only on tactical actions, without taking into account other important factors such as physical and psychological fitness.

Link & Wenninger's (2019) study examined the impact of setbacks on technical and tactical actions and performance in beach volleyball. They analysed 28,974 attack sequences of elite players from international tournaments, namely from 965

international matches from the FIVB World Series in 2012-2016 and the 2012 and 2016 Olympic Games.

The results showed that after an unsuccessful attack, players changed their stroke technique more often. The frequency of technique changes increased by 32.7% in men and 40.4% in women. Players' tactical decisions correlate with the results of previous attacks. Changes in technique do not always improve performance. The study highlights the importance of psychological preparation for quick recovery from mistakes. It is necessary to develop the ability to make effective tactical decisions under pressure. The results confirm the influence of the psychological factor on tactical decisions. Psychological training should be integrated into the training process. The sample included 12,755 male and 16,219 female attackers.

The study by Freire et al. (2022) compared the morphological and functional characteristics of elite players of classical and beach volleyball. It was conducted on 55 elite athletes: 19 men and 16 women of classical volleyball and 10 men and 10 women of beach volleyball. All tests were performed in the laboratory.

The results showed that beach volleyball players had lower levels of body fat and better cardiorespiratory performance. Male classic volleyball players demonstrated a higher elastic index in vertical jumps. Beach volleyball players are leaner and have better aerobic capacity. They demonstrate less ability to use the elastic properties of their muscles for vertical jumps. They have a greater imbalance of the posterior thigh muscles.

The authors emphasise the need to take into account the specific requirements of beach volleyball to physical fitness. It is recommended to pay attention to the development of aerobic endurance and strengthen the muscles of the posterior thigh.

The study by Papadopoulou et al. (2020) analysed the technical and tactical skills of elite men's beach volleyball teams at the 2004 Olympic Games in Athens. The study was based on the analysis of 34 matches involving the top eight teams of the tournament, with a total of 3484 game actions recorded.

The results showed significant differences between the teams in the effectiveness of serves, types of jump serves, efficiency and types of passes, as well as in the effectiveness of attacks. The Brazilian team that won the gold medal had an advantage in all these aspects. In particular, the analysis showed that the Brazilian team had the highest percentage of successful attacks (62.5%), which was significantly higher than the average of the other teams (54.2%).

The study confirmed that effective serving and efficient attacks are crucial for victory. The authors emphasise the need to focus on improving serving and attacking in the training process, especially for international players. In addition, it was found that teams that used more different types of jump serves had a higher percentage of winning points.

The study by Nunes et al. (2020) was aimed at comparing the game activity and time spent in different heart rate intensity zones in elite women's beach volleyball players during national and international competitions in order to determine the influence of the players' role (blocker or defender) and tournament ranking on the players' functional state during the match. It was conducted in the format of a case study with the participation of two female athletes: a blocker (35 years old) and a defender (20 years old). The data from GPS systems and heart rate monitors collected during 66 international and 33 national matches of the Brazilian Beach Volleyball Championship were used to study the game activity.

The results of the study showed that the blocking athlete spent statistically significantly more time in high heart rate zones compared to the defender, while the defender spent more time in the middle zones. International matches were found to be more physically demanding than national championships.

Therefore, Nunes et al. (2020) proved that blockers experience higher physical exertion than defenders, especially in international competitions. This study emphasises the need to individualise training based on the player's position and level of competition.

Oliveira et al. (2018) studied the dynamics of training load of two Olympic beach volleyball champions over three mesocycles. The aim was to determine changes in training intensity and their impact on the physical condition of athletes. The study was conducted on two players: a specialised defender and a blocker, both aged 34 with 14 years of competitive experience.

The results showed a gradual increase in training load during the preparatory period. The difference in lower limb explosive power between the defender and the blocker may be related to the different specifics of their playing activities. The study provided valuable information about the dynamics of training load in different periods of preparation. It can be useful for the development of individualised training programmes.

The analysis of the research of this block revealed the determining factors that influence competitive indicators in beach volleyball: age, game role, level of competition and intensity of the game. The structure of competitive activity changes with age, and blockers perform more jumps than defenders. In balanced matches, the duration of plays and game time increase, and the intensity increases in decisive phases. The need for an integrated approach to the training of elite players, including technical and tactical skills, physical fitness and psychological stability, is emphasised.

The main trends are psychological stability, individualisation of training and modern methods of data analysis. The training process should be adapted to the age, role and level of competition, and training should include simulations of different levels of competition. Individualisation of training programmes and the development of endurance are crucial success factors.

– **Analysis of the influence of age characteristics on competitive activity in beach volleyball**

Age is a determining factor that influences physical development, functional fitness and ability to master various technical and tactical skills of the game. Therefore, taking into account age specifics is a prerequisite for the effective organisation of the training process. This section presents an analysis of studies on the influence of age on the competitive activity of players in beach volleyball, in particular the works of Medeiros et al. (2014), Costa et al. (2021) and Da Costa et al. (2022).

Medeiros et al. (2014) investigated how the age characteristics and playing positions of players on the court affect the competitive performance and timing characteristics of the game in beach volleyball.

The results of the study demonstrated that age groups, playing positions and the level of competition have a statistically significant impact on the physical and temporal parameters of the game. In particular, in the senior age category (senior) there was an increase in the duration of sets, total rest time, the number of jumps and the intensity of physical activity performed by defenders compared to the younger categories (U19 and

U21), which emphasises the importance of physical fitness and optimisation of training load in adult athletes.

The study by Costa et al. (2021) was aimed at analysing the time characteristics and game activity of female players under the age of 21 during the FIVB Beach Volleyball World Championships 2019. Particular attention was paid to the influence of the playing role (blocker/defensive player), the phase of the competition (group stage/final) and the outcome of the set (win/loss) on competitive performance.

The analysis of 8 matches (16 sets, 556 plays) revealed that medium plays (4-7 s) are the most typical for women's U21 beach volleyball (58%). Blockers perform more competitive work (jumping, receiving the ball in motion) than defenders. The phase of the competition (final) and the outcome of the set (victory) affect the time and competitive indicators (increase in intensity, activity).

The results of the study by Costa et al. (2021) indicate the need to individualise the training process for players of different roles. Coaches are advised to take into account the specific requirements for blockers and defenders, to simulate the conditions typical for different phases of competition in training, and to develop general and special endurance, as well as the ability to recover quickly.

The study by Da Costa et al. (2022) focused on the comparison of time performance between the first and second sets and the difference in the final score on time performance in beach volleyball. The aim was to determine how these factors affect the duration of the draws, rest periods, total playing time, and the ratio of rest time to playing time. The study involved 25 men's teams (players aged 15-17 years) competing in the Brazilian School Championships.

A total of 21 matches were played, including 42 sets and 1374 draws. The focus on players aged 15-17 years allows us to study the peculiarities of competitive activity at the stage of training of youth teams, which is important for understanding the dynamics of sportsmanship development.

The analysis of the study results revealed that the time indicators in beach volleyball do not depend much on the type of set (first/second), although the total playing time tends to increase in the 2nd set. The main factor affecting these characteristics is the difference in the final score. In balanced matches, players spent more time on the actual game and had longer rallies, which is explained by the greater tension in the matches. However, the stable ratio of game action to rest indicates an efficient use of time between draws, even in intense matches.

The results of this study emphasise the importance of modelling different levels of balance (strength/count) in the training process, including balanced and unbalanced games. Coaches should take into account that in balanced matches, players spend more time on the court and perform longer plays, which requires appropriate physical training.

The identified trends allowed us to formulate conclusions and recommendations for optimising the training process in beach volleyball. The training process should be adapted to the age characteristics, game roles and level of competition of athletes, which involves individualising programmes. Preparation for competitions should include modelling different levels of competition and stages of competition so that athletes can adapt to different scenarios.

Individualisation of training programmes is a prerequisite for achieving high sports performance, as each athlete has unique needs. The development of general and specific

endurance, as well as the ability to recover quickly, are crucial factors in successful competition, ensuring that athletes are prepared for long and intense matches.

– **Competitive activity in beach volleyball: analysis of motor activity**

Competitive activity in beach volleyball is a complex and multifaceted phenomenon that includes physical, technical, tactical and psychological components. To achieve high results, it is necessary to take into account all these aspects and optimise the training process in accordance with the requirements of the competition. This unit analyses research that examines various aspects of competitive beach volleyball performance, from physical intensity to tactical decisions and physiological reactions. In particular, the work of Hank et al. (2016), Bellinger et al. (2021) and João et al. (2021) will be reviewed.

The research work of Hank et al. (2016) was aimed at evaluating the movements of elite beach volleyball players during official matches, in order to study the distances and duration of horizontal movements of athletes. The object of the study was four teams (8 players) aged 28.6 ± 5.8 years. A three-dimensional kinematic system was used for the analysis.

The results of the study showed that the average duration of one draw was 7.27 ± 3.4 seconds, and the average distance of horizontal movements during the draw was 9.39 ± 5.67 metres. The position of the player on the field (blocker or defender) did not have a significant impact on the distance covered during the game. The authors provided important information about the intensity of movements and the duration of actions during the game of elite women's beach volleyball players.

The results of this study emphasise the need to include in the training process exercises aimed at developing speed and agility, as well as improving the technique of moving on the sand.

The study by Bellinger et al. (2021) aimed to analyse the external activity profile of women's beach volleyball players during official matches in order to determine the external load of players, taking into account the level of competition, score difference and changes in external load between sets. The object of scientific observations was two groups of female athletes: ten adult players (average age 27 ± 3 years) and ten female athletes of the U23 category (U23; average age 19 ± 2 years). The data were collected during 60 matches played as part of the Australian Beach Volleyball Championships.

The results of the study showed that adult players covered a greater relative distance in speed zones 2 and 3 compared to U23 players. In the first set, players of both groups covered a greater relative distance, average acceleration/deceleration and distance covered in acceleration zones 2 and deceleration zones 2 and 3 compared to the second set. Sets that ended with a smaller score difference included a greater relative distance, higher top speed, higher average acceleration and deceleration, and greater relative distance in speed zones 1 and 3 than sets with a larger score difference.

The authors found that the profile of velocity, acceleration and deceleration in women's beach volleyball is influenced by contextual factors such as tournament level, score difference and changes between sets.

The results of this study highlight the need to consider contextual factors when planning the training process.

The study by João et al. (2021) analysed the physical fitness of women's beach volleyball teams during competition, taking into account player positions, sets and match results. The study was conducted on 12 professional players equipped with GPS devices during 30 official matches (50 sets).

The results revealed significant differences between player positions: defenders had higher accelerations and decelerations, lower movement speeds and lower jumps than blockers. High deceleration, speed, acceleration and maximum load were important for the defenders' advantage, while maximum speed and jump height were important for the blockers. The study provides a detailed insight into the physiological demands on players depending on their position. The results are valuable for the development of specific training programmes.

Thus, the general trend of scientific works in this block is the need to integrate scientific data into practical training, using modern technologies to analyse motor activity and adapting the training process to the individual needs of players and the requirements of competitions. The recommendations are that coaches should focus on the development of speed, agility, jumping endurance and explosive power, taking into account the specifics of the role and contextual factors, as well as use modern methods of analysis to objectively assess and optimise the training process.

– **Analysis of technical and tactical actions in beach volleyball**

Technical and tactical activity in beach volleyball is a complex phenomenon involving individual technical skills, team interaction, tactical decisions and strategic thinking. Success in this sport depends largely on the effectiveness of technical elements and the ability of players to adapt to different game situations. In this section, we analyse studies that examine different aspects of technical and tactical performance in beach volleyball, including Giatsis et al. (2019), Perez-Turpin et al. (2009), Palao et al. (2015), Palao et al. (2019) and Šimac et al. (2017).

The study by Giatsis et al. (2019) aimed to analyse the technique of hand movements during the attacking stroke (spike) in beach volleyball among elite players. The aim was to identify the types of arm swing techniques used by the world's top players, to assess the frequency of their use and the relationship with performance.

A study conducted on 96 male players participating in the 2017 Beach Volleyball World Championships revealed four main swing techniques: bow and arrow high, bow and arrow low, snap and circular. Analysis of match videos classified by two experts showed high reliability of technique classification (κ=0.965 for internal and κ=0.872 for inter-expert reliability).

The results showed that the most commonly used technique was the high bow and arrow (41.7%), followed by the circular technique (35.4%), the snap shot (12.5%) and the low bow and arrow (10.4%). Importantly, there were no statistically significant differences in performance between players using different swing techniques. This suggests that the effectiveness of the attack in beach volleyball is not solely dependent on a specific swing technique, but that other factors such as stroke accuracy, strength, ball trajectory, timing and tactical situation play a more important role.

The general conclusions of the study emphasise that the choice of swing technique depends on the individual characteristics and preferences of the players and does not have a direct impact on their performance. However, the authors recommend considering the potential impact of these techniques on the risk of shoulder joint and muscle injury, which requires further research. The results confirm the importance of an individualised approach to teaching attacking techniques, with an emphasis on injury prevention.

The study by Perez-Turpin et al (2009) focused on the analysis of standard and specific motor actions of women's beach volleyball players to determine the frequency of their performance and the relationship with the conditions of real competition. The aim of the

study was to develop a methodology for the quantitative analysis of the main types of movement and to study their distribution in official matches in order to determine the specific requirements for players.

The study was conducted on the basis of video recordings of four matches of the 2006 European Beach Volleyball Championships held in Valencia (Spain). The study involved 10 professional players, for whom 1646 movements were recorded during the matches. The data was analysed using SportsCode software and statistical processing in SPSS.

The main results showed that 59% of the time the players performed offensive movements and 41% of the time they performed defensive movements. In the structure of defensive actions, 24% were receiving the ball, 29% were blocking and 47% were defensive actions. Of the offensive actions, 34% were low hits, 50% were attacking hits and 16% were preparatory movements for the attack. The overall results of the study confirmed that offensive movements dominate in women's beach volleyball, but that defensive actions such as receiving, blocking and defending also play an important role.

The results emphasise the need to pay attention to both offensive and defensive actions in the training process, developing skills in performing different types of strokes and effective defence.

The study by Palao et al. (2015) aimed to analyse the time of active play and the work/rest ratio in women's beach volleyball during the 2008 Olympic Games, taking into account the playing role of the players. The aim of the study was to provide quantitative data to improve the training process.

The study, based on the analysis of 2708 games played by 48 players in 69 sets, measured the number of ball contacts, jumps, hits, duration of active actions and rest, and also took into account the players' role (defender, blocker, all-rounder).

The results showed that blockers performed significantly more jumps, but there were no significant differences in the number of touches or shots between players of different roles. The average duration of a play was 7.5 seconds and the pause between plays was 13 seconds, with a work/rest ratio of 1:5. It was also found that the pace of play was faster in the early stages of the tournament, and that draws became longer in the later stages.

The general conclusions of the study emphasise the importance of considering the role of the game and the work/rest ratio when developing training programmes. In particular, coaches should pay attention to the development of jumping endurance in blockers and model a 1:5 work/rest ratio in training.

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The results showed that the lowest performance indicators were in serving and blocking and the highest in passing and receiving. Effective players had significantly higher efficiency scores in all six techniques, especially in passing, receiving and attacking.

The general conclusions of the study emphasise the importance of high-quality performance in the main technical and tactical elements for success in beach volleyball, and also indicate the need for increased attention to the training of serving and blocking.

Summarising the analysis of the scientific works dedicated to technical and tactical activities in beach volleyball, a number of factors that determine success in this sport have been identified. Technical skill, tactical flexibility and individual training of the players are key components. The effectiveness of the attack depends not only on hitting technique, but also on accuracy, strength and tactical situation. While offensive actions dominate the game, defence, especially receiving and blocking, are equally important elements. Blockers need special training to develop jumping endurance, and receiving from underneath is recognised as the most effective way to receive a serve.

Power serves make it difficult to receive, so coaches need to pay attention to training on the move. Effective players demonstrate high quality performance in all technical elements, especially in passing, receiving and attacking. The training process should take into account the individual characteristics of the players, the balance between work and rest, and include injury prevention. Further research is needed to optimise the training process and develop effective tactical schemes and combinations.

– **An integrated approach to sports training in beach volleyball**

Modern athlete training involves an integrated approach that takes into account the interplay of physical, technical, tactical and psychological aspects. In beach volleyball this is particularly important due to the specific demands of the game.

This section analyses studies that address key aspects of the training process: the effect of special exercises on jumping endurance (Pelzer et al., 2020), the specifics of training

on sand (Lehnert et al., 2017), the role of psychological preparation (Balasas et al., 2018) and methods of recovery from exertion (Bozzini et al., 2021).

The study by Pelzer et al. (2020) aimed to analyse the relationship between external training load and internal response in beach volleyball athletes, in order to determine the effect of different types of training on physiological parameters. The study was conducted on 7 highly skilled volleyball players (2 males and 5 females) aged 18.9 ± 1.3 years. The training sessions were divided into three categories: high, medium and low jump volume.

The following markers were used to assess the body's response: delayed onset muscle soreness (DOMS), creatine kinase (CK) levels and subjective perception of exertion (s-RPE). The results showed that the greatest increase in jump height was observed after high-volume sessions, but the difference was not statistically significant. The markers DOMS, CK and s-RPE had higher values after low-volume training sessions, indicating greater fatigue from other playing activities. The general conclusions of the study are that a high volume of jumps is not the main factor affecting the body's response, and that a high load from other intense movements may lead to greater fatigue.

The results emphasise the need for a balanced approach to training, taking into account not only jumping but also other playing activities.

The study by Lehnert et al. (2017) aimed to evaluate the effect of 8 weeks of pre-season training on the physical characteristics of volleyball players, including muscle strength, power, and somatic parameters. The study was conducted on 12 volleyball players, where anthropometric characteristics, maximal lower limb muscle strength, jump height and reactive power index were assessed before and after training.

The results showed significant improvements in maximal lower limb muscle strength, especially at high speed, but slight improvements in jump performance.

The general conclusions of the research confirm the importance of pre-season preparation for the development of muscular strength in volleyball players, and indicate the need to consider the specificity of training exercises for the development of jumping power.

The study by Balasas et al. (2018) aimed to evaluate the effect of 12 weeks of beach volleyball training on the muscular performance of classical volleyball players, to determine whether training on sand improves physical characteristics such as endurance, strength and jumping height, with further adaptation of these improvements to hard surfaces.

The study was conducted on 11 volleyball players who, after completing a season of classical volleyball, underwent a 12-week training and competition programme in beach volleyball. Muscular performance was assessed before and after the programme using the following indicators: muscular endurance, muscular strength and explosive power (jump height).

The results showed that after 12 weeks of training, lower limb muscle endurance improved significantly, knee and foot extensor strength increased, and jump height increased on both sand and hard surfaces.

The overall conclusions of the study emphasise that 12 weeks of training on sand improves muscular endurance, strength and jump height in classical volleyball players and that these improvements are effectively transferred to hard surfaces.

Thus, Balasas et al. (2018) investigated the broader context of the training process, including the transfer of training effects between sports and surfaces, while Pelzer et al. (2020) and Lehnert et al. (2017) focused on narrower aspects of the training process within a single sport.

The study by Bozzini et al. (2021) aimed to assess the characteristics of physical fitness and training load of players on NCAA Division I women's beach volleyball teams in order to optimise the training process.

The study was conducted on 20 players during a 6-week competitive cycle using GPS and heart rate monitors. The results showed that the first team players had better explosive power indicators than the reserve team. The match load exceeded the training load, indicating the high physical demands of competition.

The general conclusions of the study confirm that NCAA beach volleyball requires high explosive power and is characterised by significant training loads, especially during the season. Compared to other studies, Bozzini et al. (2021) focused on analysing the workload during the competitive season and comparing the main squad and reserves using objective methods to assess training load.

Analysis of the studies included in this section revealed common trends, including the importance of both an individualised and a comprehensive approach. The effectiveness of training is not limited to physical activity alone, but requires taking into account the individual characteristics of athletes, their strengths and weaknesses, and their role in the game. A large number of jumps is not a determining factor in fatigue, while other game actions can lead to significant stress. Pre-season training plays a key role in the development of muscular strength, but requires a specialisation of training exercises to improve jumping power. Training on sand has been shown to be effective in improving muscular endurance and strength, as well as jumping height, with a positive transfer of these improvements to hard surfaces.

Beach volleyball at the NCAA level requires high explosive power and is characterised by significant training loads, especially during the competitive season. Coaches are advised to adopt a balanced approach that takes into account not only the physical but also the psychological aspects of training, as well as effective recovery methods.

– **Gender differences in physical fitness in beach volleyball**

The analysis of the research on physical fitness in volleyball revealed the need to consider gender differences in order to optimise the training process. These differences, caused by biological and social factors, have a significant impact on the effectiveness of training.

The studies by Riggs & Sheppard (2009) and Natali et al. (2019) analyse these differences, focusing on the influence of physical qualities on vertical jump height and training requirements based on role (blocker/defender) and gender.

The analysis of these studies will allow coaches to develop more effective gender and role specific programmes.

The study by Riggs & Sheppard (2009) focused on analysing the physical characteristics that influence the height of vertical jumps in elite beach volleyball players and comparing these characteristics between men and women.

The study involved 30 elite international players (14 males and 16 females) performing jumps on a strain gauge platform. The results showed that men had better strength

performance, but the biomechanical efficiency of jumping was similar for both sexes. The main factors determining jump height were relative strength and average power.

The authors concluded that the development of explosive strength and power should be a priority for both sexes, with an emphasis on exercises that stimulate the efficiency of the stretch and contraction cycle (SSC).

The results showed that males had significantly better grip reactive force (GRF) and jump height, although correlation analysis revealed similarities in biomechanical jump performance between the sexes. The results emphasise the importance of developing explosive strength and power for both sexes.

The study by Natali et al. (2019) aimed to analyse the physical and technical training requirements in beach volleyball, taking into account player position and gender. The study included 42 elite players who participated in the World Beach Volleyball Tour. The study analysed the duration of matches, the ratio of work to rest, and the number of jumps and hits. The results showed that training requirements were not gender specific, but varied according to the player's position: blockers performed more jumps. The study provides normative data for training planning, but is limited to an elite sample and a specific tournament.

Thus, the analysis of the studies by Riggs & Sheppard (2009) and Natali et al. (2019) revealed that gender differences in beach volleyball are manifested in strength and power, but do not affect the biomechanical efficiency of the jump and the work/rest ratio. The player's position (blocker/defender) has a greater impact on physical and technical demands than gender. To optimise training, it is necessary to consider both gender and position, to develop explosive strength and power, and to adapt programmes to the specific demands of the game at each position.

– **Explore other areas of beach volleyball**

The previous chapters have discussed various aspects of volleyball such as technical and tactical actions, competitive activities, training loads and gender differences. However, there are other important areas that help to broaden our understanding of the sport. In this section, we analyse the work on the effect of match workload on physiological performance and recovery (Magalhães et al., 2011), anthropometric characteristics and jump height (Batista et al., 2008), jump load using IMU (Schmidt et al., 2021), the effect of specific physical training (Hunchenko et al., 2021) and a systematic review on the physical fitness requirements of beach volleyball players (Marzano Felisatti et al., 2024).

The study by Magalhães et al. (2011) aimed to analyse the physiological and neuromuscular effects of a three-set beach volleyball match and to assess the players' recovery capacity. The study involved 16 highly skilled Portuguese players who were measured for heart rate, blood lactate concentration, jump height, acceleration rate and maximum isometric strength.

The results showed that matches are characterised by interval exercise of moderate to high intensity, causing a temporary decrease in lower limb strength and a deterioration in speed performance, but that most indicators recover after 3 hours, with the exception of the ability to accelerate.

The study by Batista et al. (2008) aimed to analyse the influence of anthropometric characteristics and jump height on game performance in highly skilled beach volleyball players. The study involved 38 players who were divided into two groups according to their rating. The results showed that players with a higher rating showed better

performance in vertical jumps, especially in attacking and blocking. There were no statistically significant differences in anthropometric parameters between the groups. The authors concluded that vertical jump height plays an important role in performance, but that success depends on a combination of factors, including technical training and tactical skills.

The study by Schmidt, Meyer & Jaitner (2021) aimed to quantify jumping loads in beach volleyball using IMU. The study involved 12 professional players who used IMU devices during matches.

The results showed that blockers performed more jumps, higher jumps and with greater acceleration than defenders. The study highlights the importance of using IMUs to monitor the training process, although it has limitations in terms of accounting for the effects of sandy surfaces.

The study by Hunchenko V. et al. (2021) aimed to determine the effect of specific physical training on the technical elements of the game in beach volleyball. The study involved 20 student volleyball players from Kherson, Ukraine. The training was carried out according to the author's programme, which included an increase in workload and the use of a special simulator.

The results showed a probable development of explosive power, speed and agility, as well as improvement of technical elements of the game. The authors concluded that the proposed methodology effectively improves the physical and technical skills of players.

The study by Marzano Felisatti et al (2024) is a systematic review of physical demands and match loads in beach volleyball, focusing on strength, kinematic and kinetic indicators. The aim was to summarise current knowledge in order to improve the training of athletes. The review was conducted in March 2024 using the databases SPORTDiscus, Web of Science and Scopus according to PRISMA criteria. Of the 19 studies selected, 6 involved males, 9 involved females and 4 involved both sexes at different levels of ability.

The results showed that men played longer, blockers performed more jumps and defenders performed more technical actions. The analysis revealed differences between gender and player level, but also the risk of bias due to limited samples. The authors emphasise the need to expand samples and to take environmental factors into account.

In conclusion, the studies in this section demonstrate a comprehensive approach to the analysis of beach volleyball using modern technologies such as IMU sensors and video analysis. They emphasise the importance of an individualised training process, taking into account the role and level of training.

Physical fitness is a key success factor, especially explosive power and speed. Matches are characterised by interval stress, which requires appropriate training and recovery planning. Differences between players of different roles and gender have been identified.

There is a need to improve the research methodology, in particular to increase the number of samples and to consider environmental factors. Coaches are recommended to use an integrated approach, modern technologies and individualised programmes. Further research should take into account the various factors influencing the game, and the results should be actively implemented in practice.

CONCLUSIONS

A review of the scientific literature on beach volleyball has revealed a number of important trends and patterns. Studies on different aspects of training and competition emphasise

the crucial role of physical fitness, especially the development of jumping power, explosive power and speed, in achieving high sporting results. Consideration of the role of the game and individualisation of the training process are also important factors.

The analysis showed that the effectiveness of technical and tactical actions, the tactical interaction between partners and the ability to adapt to different game situations are decisive for success in beach volleyball. Studies in different age groups emphasise the need to adapt training programmes to the age characteristics of athletes and the stages of long-term training. Gender differences in physical, technical and tactical characteristics also require a differentiated approach to the training process.

The use of modern technology, such as IMU, provides more objective data on the motor activity of athletes. Systematic literature reviews contribute to the generalisation of knowledge and the identification of promising research directions. At the same time, the analysis revealed certain gaps in beach volleyball research.

In particular, the issues of psychological training and a comprehensive analysis of the influence of different factors (technical, tactical, physical, psychological) on competitive outcome have not been sufficiently addressed. Promising directions for future research are also the study of the characteristics of the training of Ukrainian volleyball players, taking into account the specifics of the national training system and modern world trends.

The results of these studies will form the basis for the development of scientifically based recommendations for optimising the training process and improving the level of training of Ukrainian beach volleyball athletes.

CONFLICT OF INTERESTS

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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