PHYSICAL AND PHYSIOLOGICAL CHARACTERISTICS OF FEMALE VOLLEYBALL ATHLETES - AN ANALYSIS

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ABSTRACT
This article's major goal was to evaluate 31 research (n = 31 studies) on the physical characteristics, physiological characteristics, and on-court performances of female volleyball players. When developing yearly training plans for volleyball players, empirical and practical information derived from research on training-related concerns, such as body mass, fat-free mass, aerobic profile, strength, and agility and speed, should be combined and used. A lack of data on female volleyball players' on-court performance and time-motion analysis is one of the research issues raised in the article. Another is the need for more experimental and manipulative studies to evaluate the impact of various training regimens on the physiological characteristics of female volleyball players.

***Key Words**:- athletic performance, physical fitness, exercise test, testing protocols, training programs*

INTRODUCTION
Female volleyball coaches, strength and conditioning coaches, and other professionals who work with the volleyball player must use empirical and practical knowledge from a variety of sport-related domains, including exercise physiology and sports medicine, to develop performance-enhancement training programs. Strength and conditioning programs designed exclusively for female volleyball players may be particularly successful at implementing pertinent information on training-related concerns, such as physical qualities, physiological attributes, and on-court statistics.

In order to help those responsible for the short- and long-term planning stages of yearly training programs, an effort was made to include information on the physical characteristics, physiological characteristics, and on-court performances of female volleyball players. When these experts evaluate the impact of their programs on the growth of female volleyball players, this integrated information may also be helpful. The specialists who deal with volleyball players should exercise caution when applying the findings of research on female volleyball players, however. This means that the methodological constraints of these research and any measurement problems arising from the physical tests administered to the participants in these investigations should be considered.

The current article serves three purposes: (a) to review a number of studies (n = 31) on the physical characteristics, physiological characteristics, and on-court performances of female volleyball players, including professional players, members of the national team, and university intercollegiate players; (b) to discuss a number of methodological issues and testing limitations related to the reviewed studies; and (c) to offer helpful recommendations for volleyball coaches.

The evaluated papers were chosen after a thorough search of the English-language literature, which included the use of major computerized databases and library holding searches.

Volleyball, volleyball players, and volleyball physiology were among the search phrases used. Articles focusing on young athletes and those that combined statistics for male and female athletes were eliminated. In our assessment, 31 papers that met our criteria were taken into consideration.

PHYSICAL ATTRIBUTES

Table 1 summarizes the physical characteristics of the female volleyball players in the studies under consideration. The studied data show a number of interesting results. Between 164.3 6 4.0 cm and 62.5 6 8.0 kg to 187 6 5.4 cm and 75.1 6 7.4 kg, respectively, are the ranges for height and body mass. The genetic makeup of the players, their level of play, and the selection process they experienced are just a few of the variables that may account for these variances in the data.

Differentiating between players at various levels may depend on their physical attributes. Other research revealed that players at higher levels are taller and a little bit heavier than players at lower levels, despite one study showing no differences in height and body mass between national and university level players. One research looked at the disparities between players at various positions in Greek First National League Divisions A1 and A2.

Liberos seem to be smaller than players in other positions, according to this study's comparison of the physical features of players who play different positions. Additionally, as compared to hitters, liberos, and setters, centers and opposites were taller. Three studies looked at changes in physical traits throughout time. Following a supervised off-season strength and conditioning program, NCAA division I athletes' body mass, % fat, and fat-free mass did not change. In a different research, body mass remained consistent, but the NCAA Division I players' % fat rose and their fat-free mass declined towards the conclusion of the competitive portion of the season compared to baseline data. A other research, however, found that the % fat decreased somewhat all season long. Although a rise in body fat percentage might impair performance, it is important to highlight that the differences shown across all trials were minimal and may have been influenced, at least in part, by the accuracy of the equipment and measurement techniques. Furthermore, even if the data do really show changes in body composition, it does not follow that these changes had an impact on performance. Johnson et al.'s hypothesis that body composition might change over time led them to propose that a range of values rather than a single stringent standard should be specified for each individual athlete.

The physical characteristics that are exclusive to those players may be shown by contrasting volleyball players with athletes from other team sports and with nonathletes. In one research, college volleyball players had greater body mass and fat-free mass than nonathletes and were noticeably taller. The volleyball players had shorter arms than college basketball players but were of comparable height and body mass. In a different research, the physical characteristics of Greek division 1 basketball, handball, and volleyball players were compared. Basketball and handball players were found to be shorter than volleyball players.

Determining whether or not a physical attribute is connected to success is perhaps the most crucial part of explaining it. According to a recent analysis of the physical traits, physiological traits, on-court performances, and dietary practices of male and female basketball players, height and a larger arm span were connected with the best teams in one tournament but not the lowest teams. However, only the results of 2 research were used to

support this statement. Similar to this, we only came across 3 research that looked at the connection between performance and physical traits.

In one research, players on the most successful and least successful teams in a 1977 invitational volleyball tournament differed significantly in terms of body fat. In a different research, a substantial correlation between height and the results of a 1974 US National Championship Tournament was discovered. Finally, no associations between anthropometric factors and spike velocity in NCAA division I athletes were discovered.

Although findings from two correlative studies support the hypothesis that body fat and height impact volleyball player performance, there is currently no solid scientific evidence to support this idea. To determine how much physical characteristics contribute to real performance, further research is required. In addition to the obviously significant factor of physical characteristics, success in sports is influenced by a variety of factors, including the physiological characteristics of the athletes and their psychological condition.

A strong aerobic capacity is nevertheless essential for volleyball despite its intermittent nature, particularly in multiset matches when sustaining a high level of performance over time is necessary.

The program's endurance component comprised four weekly 30-minute workouts at 80% of one's maximum heart rate. A 2-mile run at maximum effort was used to measure endurance capacity. No variations in running times between starters and nonstarters were seen in the initial values.

STRENGTH

Having strong muscles is essential for doing well in sports. Muscle strength may be measured in a number of ways, and different research use various techniques. Thus, it is challenging to compare the findings of different investigations.

We discovered 4 studies that investigated the impact of a resistance training regimen on various strength metrics. One research looked at NCAA division I players to see how a 12-week off-season training Physical and Physiological Attributes of Female Volleyball Players program affected them. The weekly workout schedule included 2 plyometric sessions and 4 resistance training sessions. In terms of concentric type exercises, baseline data indicated that beginners were generally stronger than nonstarters (e.g., 1 repetition maximum bench press: 45.7 6 7.1 kg vs. 38.6 6 3.8 kg, respectively). Even after dividing absolute values by fat-free mass, starters continued to outperform nonstarters in strength. Exercises of the isometric and isokinetic kind did not reveal any differences between starts and nonstarters, however. Another research looked at the leg extension isometric force in two groups of athletes from Finland's national volleyball league during the competition phase. The force output in the control group, which underwent 1-2 endurance and strength exercises per week, did not increase. The experimental group took part in three to four preseason conditioning sessions and two to three sessions throughout the competitive portion of the season. In the middle of the season, during the course of four months, the maximum rate of force development dramatically rose. By the conclusion of the season, peak force had not increased and had even decreased. This decrease in maximum force happened five weeks after resistance training was stopped. This research highlighted how the quantity of overall endurance and volleyball drill training may have hampered the development of strength. But it's also possible that the testing process missed variations in dynamic strength. The players did not engage in

isometric exercise, in fact. It's likely that the strength levels might have increased with various strength testing procedures. Last but not least, a 6-week isokinetic resistance training program raised knee extension values at a velocity of 180°•s21 but failed to increase upper-body strength as evaluated on an isokinetic machine.

Success in a national volleyball competition also found to be correlated with vertical jump ability. In the 1974 US National Championship Tournament, the teams' final rankings were connected by standing reach, vertical leap, and absolute jump height (11). The authors of this research hypothesized that there is a "critical height" above the net for ideal spiking and blocking, and that players who are able to cross this barrier have an advantage over those who are unable to do so. A subsequent research (22) did not, however, discover that VJ performance contributed to differentiating between winning and losing teams. In a study of NCAA division I female athletes, no connections between VJ and spiking velocity were discovered. Although it is believed that VJ ability influences volleyball play, there is a dearth of information addressing its significance in forecasting success and distinguishing between successful and losing teams.

It's critical to ascertain if certain training regimens can support season-long maintenance or even improvement of jumping ability. After 7 weeks of intense in-season resistance training, a number of VJ values in one research failed to rise. In reality, the approach jump and reach numbers dropped from 61.2 cm to 57.9 cm. This 7-week period was then followed by 4 weeks of ballistic resistance training with lighter loads, which significantly increased those VJ metrics and brought the jump height back to baseline values at 61.0 6 5.6 cm. In this research, typical resistance training not only failed to enhance jump performance but also saw a drop in jump power and velocity values. In contrast, the force, velocity, and power levels of the different VJ protocols carried out increased after ballistic training.

After a 12-week in-season ballistic-style resistance training program, another research demonstrated a statistically significant rise in CMJ values among top Portuguese Division 1 players. The number of countermovement leaps with weights of 10, 20, and 30 kg significantly increased as well. Ballistic training is crucial for improving VJ, but it should only be used once a solid resistance and technique training base has been established. This research emphasized the need for novice athletes to stay away from jump training with big weights. Instead, they have to concentrate on boosting their power and stamina as well as their jump technique.

After 12 weeks of supervised off-season training that included strength training, plyometric training (twice per week), and aerobic training, a third research found improvements in both VJ and running VJ. The running vertical jump went from 47.6 6 5.0 to 51.8 6 5.6 cm, while the vertical jump increased from 44.7 6 5.7 to 48.0 6 4.2 cm. Even after a further 12 weeks of unsupervised instruction, there were no noticeable improvements in VJ performance.

Last but not least, a research that had participants practice exercises at both slow and high angular velocities for six weeks demonstrated gains in block jump and spike jump performance. Instead of reporting values as the difference between standing reach and maximum jump height, the highest height that was attained was given. Additionally, standard deviation was stated rather than SD. The block jump and spike jump's baseline measurements rose to 271.7 6 2.2 cm and 284.462.3 cm, respectively. Only participating in volleyball sessions, the control group's VJ performance did not increase.

Strength and conditioning instructors want to increase their athletes' VJ performance throughout the course of the training regimen. In one research, athletes who exercised for endurance and strength 1-2 times per week during the full season showed no changes in VJ values. In contrast, VJ values rose in a group of athletes that engaged in 3–4 times per week of endurance and strength training for 7 weeks of their preparation phase and 2–3 times per week of training for their first competition phase. During the last five weeks of the second competition phase, when strength training was discontinued, VJ dropped.

In the first two weeks of the 2005–2006 preseason, there were 17 practice sessions, 10 strength training sessions, and 1 rest day. Values for the spike jump and block leap did not dramatically alter during the course of the season. The additional 7 sessions held during the 2004–2005 preseason may have contributed to weariness and diminished performance.

Athletes utilize a variety of ergogenic aids to enhance VJ performance, including compressive clothing like tights and elastic shorts. Compression clothing was the subject of one research that looked at jump performance. 18 NCAA Division I athletes were tested on 10 maximum CMJs while keeping their hands on their waists during the leaping maneuvers. The compression shorts helped sustain power output throughout several leaps even if they had no effect on the maximum jump power. Although the advantages of wearing compression shorts were not fully understood, the authors of this research hypothesized that they could be related to the heightened proprioceptive signals brought on by the tight feel of the clothing. These results need more study to be confirmed.

Agility and Speed

Virtually every defensive and attacking move a volleyball player makes requires both agility and quickness. There are several agility and speed test methodologies available, making it challenging to compare results from different research. When selecting a test protocol among those described in the literature, researchers are urged to take specificity into account.

Two studies looked at how female volleyball players' agility and quickness were affected by strength and conditioning training. A 12-week off-season conditioning program that includes four weekly strength training sessions, two weekly plyometric sessions, and four weekly endurance sessions was put NCAA division I starters and nonstarters through. Speed A portable stopwatch was used to record the length of each run. The 12-week conditioning program actually decreased performance in the agility T-test (pre: 10.87 6 0.34 seconds, post: 11.16 6 0.38 seconds), but no changes were seen in the 10-yd and 40-yd sprints, according to data that was compiled for both starters and nonstarters. These numbers, according to the authors, largely reflected the 12-week program's absence of speed and agility exercises, and it is probable that strength and plyometric training alone cannot significantly increase speed and agility. Another research looked at NCAA division I volleyball players' responses to two weeks of preseason training over the course of two seasons. In the first two weeks of the 2004–05 preseason, there were 24 practice sessions, 12 strength training sessions, and 2 rest days. In the first two weeks of the 2005–2006 preseason, there were 17 practice sessions, 10 strength training sessions, and 1 rest day. Before the preseason, after the preseason, and at the conclusion of the season's competitive phase, an agility T-test was conducted. The T-test was conducted with running lengths that were comparable to those in the research by Fry et al. on one half of a volleyball court. T-test performance during the 2004–2005 season declined from baseline levels by the end of the preseason but then rebounded to baseline levels by the

conclusion of the competitive portion of the season. In contrast, the T-test performance during the 2005–2006 season notably increased after the conclusion of the preseason compared to baseline values and continued to increase as the competition portion of the season neared its conclusion. These findings imply that athletes could have been unduly exhausted after the 24 practice sessions and 12 strength training sessions that made up the 2004–2005 preseason. Even though there were 2 less strength training sessions and 7 fewer practices in the 2005–2006 season, the athletes' performance increased.

An imbalance between the training load and recuperation might occur as a consequence of the preseason program's intensity. Coaches need to be aware that excessive training might result in poor performance. Specifically, functional overreaching, nonfunctional overreaching, and overtraining should be understood by volleyball coaches as well as strength and conditioning trainers. Functional overreaching is a condition in which training stress-induced decreased performance finally results in improved performance following recuperation. When the training load exceeds the recuperation time permitted, a condition known as non-functional overreaching occurs. Performance is diminished for a brief period of time, often without any obvious physical or psychological symptoms. Last but not least, overtraining is a condition in which an excessive amount of training combined with a lack of proper rest results in long-term performance reductions accompanied by physiologic and psychological maladaptations.

One research made use of a novel testing device that was a 6-m-3-m platform with an integrated force platform. 29 NCAA division I–III athletes ran 4 times, 5 m back and forth, beginning and finishing on the force platform. Between division I-III players, there were no discernible disparities in running timings. There was a strong correlation between agility running times and CMJ heights. In fact, 34% of the variation in agility running times could be accounted by jump height. Finally, a discriminate analysis that looked at what separated the successful teams from the losing teams in these Divisions discovered that agility was a key differentiator.

ON-COURT PERFORMANCE

It is important to assess physiological indicators on the volleyball court, such as heart rate and blood lactate, in order to provide coaches accurate information about the game's physical demands. It's important to gather and evaluate data on the movements and activities that volleyball players typically do when playing the game. These measures are made using notational analysis or time-motion analysis, which are methods for counting and categorizing player motions during a game. Unfortunately, we did not come across any research that used time-motion analysis, but we did find two studies that looked at physiological factors on the court. Men's volleyball rallies typically last fewer than 12 seconds, with a range of 3 to 40 seconds, according to time-motion research. There were also 12 second or shorter rest intervals in between rallies. Although it may seem enticing to assume that female volleyball players' rallies are comparable to those of male players, this cannot be established without also conducting time-motion analysis in women's matches.

Six non-elite female volleyball players had their heart rates monitored throughout sessions and matches for one research. During practice, heart rates varied from 120 to 161 beats per minute, with an average of 134. Heart rates varied from 116 to 172 b•min21 and averaged 139 b•min21 throughout a real game. The mean heart rate peaked while spiking and fell

during serving. Volleyball play found to be only moderately demanding for this small group, with heart rates equivalent to 55–60% of V_ O2max.

Lactate concentrations were measured in players from the inaugural German league in 1983–1984 in a different research. Between before and after the game, lactate levels stayed at around 2-2.5 mmol•L21. The authors of this research noted that just a little amount of anaerobic glycolysis contributes to the energy needs for volleyball matches, with the majority of the energy coming from phosphagen breakdown. Although theoretically possible, further study is required to fully comprehend the metabolic pathways used during female volleyball matches.

CONDITIONING FOR VOLLEYBALL

Strength and conditioning coaches may develop effective conditioning programs by using data from on-court performance studies and trials looking at ways to improve physiological factors. A brief overview of volleyball fitness regimens is necessary, even if a thorough evaluation is beyond the purview of this paper. According to a recent study by Hedrick, a training regimen for high-level volleyball performance must be tailored to the sport's needs. The motions that will be used during a game should be the basis for exercise. For instance, volleyball often involves lateral movements, but the majority of strength exercises are carried out in the sagittal plane. As a result, coaches should include exercises like lateral squats and side lunges into their training regimens. Also included should be plyometric workouts like lateral box jumps and lateral bounds. Dumbbell exercise should also be regarded as a crucial component of the fitness regimen since it enhances balance and body control. Additionally, trunk exercise is important since volleyball includes sprinting, twisting, and leaping, all of which put a lot of strain on the back. Exercises for the trunk are often done while reclining. On the basis of the specificity principle, certain volleyball workouts should be performed while standing.

A strong upper body must go hand in hand with a strong trunk. Strong upper body muscles can assist avoid injuries with the shoulder joint musculature, which is emphasized in volleyball, and will enable higher-velocity spikes and better VJ. Lastly, because VJ is one of the most crucial components of the game, training should focus on developing it. Hedrick outlined a thorough fitness regimen based on the aforementioned ideas in a subsequent paper.

METHODOLOGICAL AND MEASUREMENT CONCERNS

Three methodological and measurement issues are examined in light of the studies that have been evaluated that deal with the physical characteristics, physiological characteristics, and on-court performances of female volleyball players. (A) The paucity of time-motion analysis research. Data on the physiological characteristics of female volleyball players during live games were only collected in 2 research. The development of effective training programs requires knowledge of the real game activities that players carry out, such as the quantity of VJ defensive maneuver performances. There is a need for additional research gathering information on volleyball's on-court performance, just as there is in other sports (like basketball). A thorough study of the on-court performances should be done, along with a systematic monitoring of the key behaviors shown by volleyball players throughout matches. Strength and conditioning coaches may successfully organize their strength and conditioning programs and tailor them to the unique requirements of each player by having a thorough grasp of the physiological demands volleyball players face throughout a game. (a) A dearth

of experimental research. Recent reviews of observational and experimental studies on the physical characteristics, physiological traits, and VJ of female and male basketball players made the case that more research is needed to support the use of conditioning programs for power, strength, and agility that include at least one intervention group and one control group. This finding may also be drawn from the most recent analysis of female volleyball players. There were only 4 studies that looked at how a resistance training program affected various strength metrics. To examine the efficacy of the various strength and conditioning regimens offered to female volleyball players, further multigroup studies are required. The information gained from these studies will aid coaches in evaluating the impact of various programs to the growth of their players and enable them better fit the program to the unique requirements of each player. (c) Using various testing environments and methodologies. The research under evaluation used a variety of physiological attribute testing, including agility, speed, and VJ tests. It is crucial to understand the precise protocol of the test, as well as the chosen testing apparatus and environment, in order to compare results from other research. Additionally, standards created based on the outcomes of a single physical test cannot be utilized to judge the outcomes of a different test. Therefore, the testing procedure and tool should be chosen with caution. For instance, if the researcher's goal is to examine the players' capacity to leap while spiking, then a jumping test that permits approach and the use of hands should be used. In this instance, the test need to resemble the distinct behaviors shown by the player when leaping in a real game.

PRACTICAL APPLICATIONS

Three practical implications are proposed for volleyball coaches and strength and conditioning coaches who deal with female volleyball players in light of the examined research. (A) When designing strength and conditioning programs, the quantity of exercise should be carefully evaluated. A suitable balance between volume and intensity of training, as well as sufficient recovery intervals between training sessions, are needed to reach a high level of competency in volleyball. Overtraining and overreaching may happen if the amount, intensity, and frequency of training are not balanced properly. Although functional overextending may eventually result in improved performance, both nonfunctional overextending and overtraining can have both short- and long-term negative effects on performance. It is challenging and relies on clinical results to differentiate between nonfunctional overreaching and overtraining. "Prolonged maladaptation" of the athlete and of a number of biological regulating processes is a crucial phrase in the identification of overtraining, nevertheless. Maintaining the proper balance between training and recovery is crucial in observing the players' activities during the annual training program (see a review by Meeusen et al. on overreaching and overtraining for more information). Overtraining is also characterized by decreased performance, increased fatigue, and stress (34). (b) Power training, also known as ballistic or plyometric training, should be a part of the volleyball program. As the present analysis has shown, conventional resistance training is insufficient to help female volleyball players perform better, particularly when it comes to the VJ—blocking, serving, and spiking—skills. To allow the athletes to increase their leg muscular power in the overall conditioning program, explosive-type strength training and plyometric training in particular should be incorporated in the training program. (c) Injury prevention should be taken into account while designing condition- ing programs. For instance, novice

players should steer clear of jump training with big weights and should instead concentrate on building strength and perfecting their leaping technique, as indicated by Marques et al. Ballistic training shouldn't start until a solid strength training base has been established. Another example of an overuse injury is patellar tendinopathy, sometimes known as jumper's knee. This condition is more common in athletes who exercise on hard, unforgiving surfaces and may be brought on by increasing the amount of jumping training. The kind of terrain the sportsmen train on is thus quite important.

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