A REVIEW STUDY ON PLYOMETRIC TRAINING AND ITS IMPACT ON VOLLEYBALL PLAYERS

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Abstract
Plyometric training is often employed in volleyball, which is thought to be a very explosive and quick-paced sport. Reviewing plyometric training's impact on volleyball players' performance was our aim. For the sample that was included, no restrictions were placed. The interventional studies that used plyometric training for athletes were the focus of the search. Five more items were discovered and added to the 1831 already found. After removing duplicate files and screening titles and abstracts, 21 papers remained for in-depth examination. The vertical leap was the main skill examined in plyometric training treatments, followed by strength, the horizontal jump, and flexibility, according to the findings. Additionally, it was shown that female athletes who were young (under 18) were the subjects of the most research. Plyometric training seems to improve volleyball players' vertical leap, strength, horizontal jump, flexibility, and agility/speed, according to the research that were reviewed. To fully comprehend the advantages of plyometric training on volleyball players' performance, additional research is necessary.

Keywords: plyometrics, performance, jump, strength

Introduction
Volleyball is a highly anaerobic sport that features rapid movements interspersed with brief rest intervals. Consequently, it is believed that an essential component of good athletic performance is explosive strength, which is defined as the capacity of a person's neuro-muscular system to display strain in the shortest amount of time. In truth, power results when maximal strength is paired with speed and agility. Sprinting, leaping, and sudden changes in direction all need a lot of muscular power, which allows a particular muscle to accomplish the same amount of work in less time or a bigger magnitude of effort in the same period. Indeed, research has shown a high correlation between vertical jump performance and power metrics.

A complicated action like a vertical leap requires the synchronization of several muscles in the trunk, arms, and legs. Given that each player makes more than 250 leaps throughout a five-set volleyball match, leaping ability has been highlighted as one of the most important determinants of excellent performance.

In reality, a number of studies have shown that an athlete's performance level may be predicted by the results of a vertical jump test. For instance, Smith discovered that Canadian national volleyball players performed their vertical jumps while spiking and blocking better than Canadian university volleyball players. Additionally, Ziv and Lidor found that teams with players with high vertical leaps performed better when comparing vertical jump in male and female volleyball players.

Jump training is often linked to plyometric exercise, and in particular, to exercises that put the musculotendinous unit under stress. De Villarreal discovered that bodyweight plyometric

exercises such countermovement jumps, depth jumps, and squat jumps together increased vertical jump height by 4.7% to 15%. However, by strengthening the neural system via this form of exercise, the stretch-shortening cycle, which consists of a rapid stretching action followed by a quick shortening movement, may respond more swiftly. Additionally, since this exercise involves muscle lengthening, it may also increase the amount of elastic energy that is stored in the muscles, excite more muscle units, increase the frequency at which the muscles fire, and enhance joint proprioception.

The notion of training specificity states that when the training activities correspond to the task, training adaptations are effectively transferred. Plyometric volleyball training includes rapid, explosive tosses as well as workouts that entail leaping, hopping, and bounding. The improvement of agility is also connected to such motions. This capacity is assumed to be a reinforcement of motor programming brought about by neural adaptation of muscle spindles, Golgi tendon organs, and joint proprioceptors as well as neuromuscular training.

When designing strength training regimens, the athlete's age and sex should also be taken into account. For instance, throughout adolescence, changes in the muscular, neural, and hormonal systems brought on by the growth spurt associated with puberty affect adolescents' capacity to carry out motions. The female growth spurt also starts around two years sooner than the male spurt and plateaus at about 15 to 16 years of age, while men continue to develop until they are 19 to 20 years old. When compared to their male counterparts, female athletes were shown to have weaker quadriceps and hamstring muscles in adulthood because of these alterations throughout adolescence. These differences are a result of the two sexes' various capacities for producing strength, which affects their capacity to leap, as well as their respective motor patterns.

Although plyometric training has been extensively employed in volleyball, there is insufficient scientific data to assess its potential effects on the many performance-related factors. The purpose of this systematic evaluation was twofold after that: (i) to assess the effectiveness of plyometric training programs on both male and female volleyball players, and (ii) to comprehend how those programs affected players depending on their age.

Materials and Methods

Selection Criteria

The suggested reporting elements for systematic reviews and meta-analyses were followed throughout the article screening procedure. Interventional studies that offered a plyometric strength program in volleyball team sports and performed statistical analysis to assess the connection between the applied training and its effects regarding performance were included in the inclusion criteria. The participant sample was not constrained in terms of age, sex, playing ability, previous playing experience, etc. Reviews of the literature, summaries, conference proceedings, and master's and doctoral theses were not included.

The authors of the current research checked the abstracts of all the discovered papers against the predetermined selection criteria. The researchers debated instances of dispute until an agreement was reached. The full-text version of every article was also screened using the same procedure. Additionally, a few pertinent publications were added that, maybe because of differences in the vocabulary used to describe plyometric exercise, were missed in the first literature search.

The two reviewers independently evaluated the risk of bias within the studies by taking into

account the following: (i) bias in participant selection; (ii) bias in classification of interventions; (iii) bias resulting from deviations from intended interventions; (iv) bias from missing data; (v) bias in measurement of outcomes; and (vi) bias in reporting outcomes selectively. The evaluation did not include studies that were biased in any of the areas. The Kappa index test was used to measure agreement amongst reviewers, and the resultant score of 0.89 indicated a very excellent level of agreement.

Assessment of Methodological Quality

The STROBE Statement, a 22-item checklist regarded as crucial for the proper reporting of observational studies, was used to evaluate the methodological quality. The introduction methods, results and discussion sections, the paper title and abstract, and any other relevant material are all included on this checklist. 18 of them are shared by all three designs, and four of them have distinct variations for all or part of their components. In case-control studies, information should be provided separately for cases and controls, or in cohort and cross-sectional studies, for exposed and unexposed groups. The points for all 22 elements were added together for each article's classification, and the result was divided by the maximum number of points that may be given: 22.

Each of the observers individually categorized each of the article's items before conducting an examination of interobserver reliability. An outcome of 0.94 on the Kappa index test indicated extremely strong agreement amongst observers.

Data Extraction and Analysis

All of the writers of the publications that made up this research addressed how the information about the studies' features and the findings of the evaluated measurement qualities should be arranged. Following that, information on the participant characteristics and the effects of plyometric exercise on the physical component examined in each study was retrieved by two independent reviewers.

Results

Search, Selection and Inclusion of Publications

1381 files were discovered via the database search, and five more were contributed from other sources. Another 1016 items were eliminated during the screening of the remaining 1072 files for relevancy using their titles and abstracts. Another 24 articles were eliminated after reading the entire texts of the remaining 56 papers since they did not pertain to the particular goal of the present research. additional 13 publications were cut out of the last round of screening either because they didn't include any experimental interventions, included other sports in their study, incorporated additional strength approach training, or evaluated the impact of training on postural control. Nineteen files were approved for inclusion in the current review once the screening procedure was finished. 1381 files were discovered via the database search, and five more were contributed from other sources. Another 1016 items were eliminated during the screening of the remaining 1072 files for relevancy using their titles and abstracts. Another 24 articles were eliminated after reading the entire texts of the remaining 56 papers since they did not pertain to the particular goal of the present research. additional 13 publications were cut out of the last round of screening either because they didn't include any experimental interventions, included other sports in their study, incorporated additional strength approach training, or evaluated the impact of training on postural control. Nineteen files were approved for inclusion in the current review

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Data Organization

The effects of plyometric training on the various physical fitness components examined in volleyball players were the basis for grouping the results for this research. The three writers of the current study separately grouped the publications into several research categories. The three writers talked things out until they came to an agreement to settle disagreements.

Effects of Plyometric Training on Vertical Jump Performance

Inferences concerning the effects of plyometric exercise on vertical jump performance were made in 14 of the 19 publications that made up this systematic review. The squat jump, countermovement leap, drop jump, standing vertical jump, single leg jump, and repeated jumps were among the vertical jump tests utilized in these investigations. Eleven of the 14 studies that provided information on the effects of plyometric training on vertical jump performance were done entirely on women between the ages of 14 and 22, the most of which were female athletes under the age of 18. Two of the studies examined the effects of plyometric training in both men and women; no research specifically examined the effects of plyometric training in males.

The overall duration of the intervention ranged from four to sixteen weeks, while the training regimens varied between two and three training sessions per week. The typical procedures lasted six to twelve weeks. Improvements in vertical jump performance were shown after the intervention in every study. A standard gymnasium floor, grass, or concrete were used for different plyometric training regimens, and some research even included water plyometric exercises. The typical gymnasium floor, nevertheless, was the location that was used the most. Leg leaps, single-leg jumps, hurdle jumps, drop jumps, box jumps, and lunge jumps were often used into training regimens. The most popular upper-body activity was throwing a ball.

Under-14 female athletes who underwent a four-week water plyometric training intervention saw a 3.9 cm increase in their vertical leaps. After six weeks of consistent plyometric training on a gymnasium floor, athletes under the age of 15 also saw an improvement in their vertical jump measurements. Players under the age of 17 who participated in a 12-week plyometric training program showed gains in counter-movement leaps of 16.9%. Additionally, for the same test among female players under the age of 22, an improvement of 27.6% was seen after 12 weeks of plyometric training. In a research including both male and female athletes, it was shown that four weeks of plyometric training treatments on grass and concrete led to improvements in the players' counter-jump performance of 3.34 cm and 3.67 cm, respectively.

Effects of Plyometric Training on Strength Performance

Four of the 19 publications that were a part of this systematic review made conclusions concerning how plyometric training affected athletes' strength performance. The strength tests comprised those for isokinetic peak torque of the hamstrings, lower limb peak torque, weight and plyometric training. Three of these studies—two with male volleyball players and two with female volleyball players—were carried out while the participants were between the ages of 14 and 21. No research compared the outcomes for men and women. Each of the four trials was a cohort study that included either a six-week or a 12-week intervention period.

Research has emphasized the impact of aquatic plyometric training on strength performance,

which enhances the concentric peak torque in the dominant leg, in addition to the effects of plyometric training on the stiffness of the lower limbs. Furthermore, isokinetic peak torque is increased by 13% on the dominant side and 26% on the non-dominant side after weight training sessions that include exercises for the upper body, lower body, and trunk.

Effects of Plyometric Training on Horizontal Jump

This systematic review comprised four research that provided conclusions about the impact of plyometric exercise on the ability to do horizontal jumps. The standing long jump and the depth leap long jump were two of the exercises in the horizontal jump exams. Participants in one research were both men and women, whereas those in another study were all men and all women. The participants' genre was not reported in the research by Milic et al. The other two studies were randomized controlled studies with 12-week intervention periods with athletes between the ages of 18 and 24 years. Two studies are cohort studies involving competitive-level young players (one of which used a six-week intervention period and one of which used a 16-week intervention period).

After the plyometric training intervention, studies by Milic' et al. and "menl" et al. showed a considerable improvement in horizontal jump performance. Another research did not find any significant changes in this area, while Gjinovci et al.'s study found just a modest impact of plyometric training on horizontal jump performance.

Effects of Plyometric Training on Flexibility

Inferences on the effects of plyometric exercise on flexibility were only reported in two of the papers included in this systematic review. The sit and reach test, which assesses the hamstring and lower back's flexibility, served as the basis for the flexibility measurement. These two studies had young female volleyball players as participants. With a 12-week intervention time, one study was a cohort study, while the other was a randomized controlled trial with a 12-week intervention period. These studies' findings suggest that plyometric exercise may increase flexibility by 9% to 14%.

Effects of Plyometric Training on Agility/Speed

Three papers that looked at the impact of plyometric training on volleyball players' agility and speed were identified by this systematic review. In two of the three investigations, young female volleyball players were included; in the third research, male volleyball players between the ages of 18 and 22 were involved.

According to the findings of one research, participants' speed was greatly enhanced after an eight-week intervention period [46]. A post hoc study revealed improvements in speed values for a 20 m sprint, supporting these findings. Finally, it was shown that following a 12-week plyometric training program, individuals who finished the exercise while using a weighted vest had better increases in agility than those who did not.

Discussion

Effect of Plyometric Training on Vertical Jump Performance

With the help of the stretch reflex and the naturally elastic components of the muscles and tendons, plyometric exercise increases the force of future actions. It is anticipated that plyometric training may improve athletes' jumping performance because the ability to maximize the elastic and neural benefits of the SSC, well-developed strength, and the rate of excursion of the activated musculature during the contraction heavily influence jump performance ability. In reality, research consistently shows that plyometric exercise enhances

eccentric muscle control, knee flexion, and hamstring activity, all of which help to optimize landing mechanics.

Furthermore, these advantages were shown regardless of age and in both men and girls. Theoretically, after implementing a plyometric training intervention, significant gains in jumping performance should be shown, with counter-movement or drop jumps showing greater benefits than squat jumps.

This theory is supported by the observation that drop jumps and counter-movement rely more on SSC than squat jumps do. A pause during the amortization phase of a squat leap causes the dissipation of elastic potential energy and a reduction in the potentization effect based on. Improvements of 3.17 and 2.17 cm, respectively, in squat jump performance and of 3.34 and 3.67 cm, respectively, in counter-movement were shown in a research that compared plyometric training on grass with plyometric training on concrete. The conclusion that plyometric training is more advantageous for volleyball players' countermovements and drop leaps cannot be generalized based on these two research alone. It's crucial to highlight that a comprehensive examination of female athletes from various sports has backed such a concept. Because of this, research on volleyball players in the future need to use several vertical jump tests to examine the various impacts that plyometric training has on players' abilities.

There is a definite trend in the publications under evaluation right now to study young female players. Only a few research examined the effects of plyometric exercise on adults, and none of the studies included in the review focused only on male subjects. Understanding the broad impacts of plyometric training on volleyball players is limited by this. In actuality, several elements including age, maturity, sex, or training level may affect how effective plyometric exercise is. Among these factors, maturity looks particularly likely to have a determining role in determining how well and how quickly athletes respond to plyometric exercise. No research, meanwhile, examined the athletes' level of development in the publications we studied. In future study on young athletes, this critical research gap should be taken into account and closed.

The design of the training program and the duration of the intervention period may also have an impact on how well plyometric training works. Researchers often talk about the sort of exercises utilized, the length of the training session, the state of their recuperation, and the frequency, volume, and intensity of the training when discussing the training design. However, little is known about other potentially significant contemporaneous variables that might account for some of the discrepancies in the findings. In fact, none of the examined studies' procedures included the leaping method or the impact of movement amplitude or ground-contact duration.

Effects of Plyometric Training on Strength

The development of various different athletic demands is necessary for the complicated sport of volleyball. Strength is one of these requirements since it's important for the technical volleyball abilities like leaping, hitting, and blocking. Therefore, one of the most crucial elements that gives players a benefit during elite-level tournaments is physical strength.

Four studies examined the impact of plyometric exercise on strength. The strength testing comprised hamstring peak torque measurements, combined weight and plyometric training, and lower limb isokinetic peak torque tests. Plyometric exercise increased muscular strength

in both sexes and all of the age groups examined.

One of the evaluated research revealed that plyometric training enhanced participants' strength performance in the dominant leg of under-15 women, in addition to the effect of plyometric training on the stiffness of lower limbs. Additionally, strength performance was enhanced in under-17 men and women when weight and plyometric training were mixed with exercises for the upper body, lower body, and trunk. Furthermore, plyometric exercise was demonstrated to increase strength in under-15 women, increasing isokinetic peak torque on both the dominant side (26%) and non-dominant side (13%). The findings showed that plyometric exercise enhances strength independent of the number of training weeks or the methods utilized for evaluation. The stiffness test, in contrast to the findings of the review, showed no significant alterations for any variables following 10 weeks of plyometric training in a research that evaluated the degree of particular lower limb power and reactive force in young female volleyball players.

Plyometric training involves the right technical skill as well as adequate levels of muscle strength and joint coordination, boosting the inter- and intra-muscular capacity to contract and create force, which is one reason for the strength improvements. It seems, however, that a combination exercise regimen may also enhance muscular strength.

As mentioned in Ziv and Lidor's research, at least eight weeks of training are required, specifically for motor capacity, for the development of strength, especially when the participants are young. This may account for the findings of three of the four studies in this review that examined six-week plyometric training programs in youth athletes.

Beyond the limited studies that have been published, the plyometric impact on crucial strength measures such force generation rate in both concentric and eccentric phases is not well supported by research. The development of future research should take such an approach into account.

Effects of Plyometric Training on Horizontal Jump

Four studies including both sexes and participants between the ages of 14 and 24 years old examined the effects of plyometric exercise on horizontal jump performance. Plyometric exercise improved horizontal jump in both sexes and in all age groups. Tests included unilateral jumps with either no steps or one step taken, standing long jumps with depth leaps and triple standing jumps. After 12 weeks of plyometric training in the standing long jump, senior female athletes showed meaningful improvements of 7.6%, under-16 athletes showed improvements of 7.6% after 6 weeks of training, and 12- to 19-year-old athletes showed improvements of 3.6% after 16 weeks of training.

These results imply that plyometric training improves horizontal jump performance, but at a slower rate than the 9% to 28% previously found for vertical jump performance. The specificity of plyometric training and the adjustment of the force vector and muscle activation during the exercises are two potential explanations for why plyometrics have a smaller impact on horizontal jump performance than on vertical jump performance. Additionally, horizontal leaping demands both vertical and horizontal motions, therefore the greater intricacy of the method may be the cause of the plyometric training's diminished results. However, in order to maximize this capability, further research needs be done to understand the processes that result in improved horizontal jumps, and the plyometric training program may need to incorporate more horizontal jumping activities. It is conceivable to assume that

the specificity of plyometric training need to be taken into account in the training effects, specifically, to enhance the direction of the forces and translate the advantages for the field.

Effects of Plyometric Training on Flexibility

Flexibility is a specific motion for a certain joint, and the outcomes vary depending on the activity. The sit-and-reach test was used to assess hip and back flexibility as well as lower limb extension (hamstring) flexibility. Plyometric exercise increases flexibility in under-16-year-old women, according to the findings of both studies that looked at flexibility. Although there haven't been many research that look at how flexibility affects volleyball players and how well it improves vertical jump ability, the results are murky when compared to results from studies involving athletes from other sports. On the one hand, hamstring flexibility (as determined by the knee extension angle) is linked to a reduction in the height of the vertical jump in high school students, while on the other hand, flexibility is said to be a major contributing factor to youth football players' agility, speed, and kicking.

Effects of Plyometric Training on Agility/Speed

Few research have investigated the idea that plyometric exercise might enhance volleyball players' agility and sprinting performance [Theoretically, plyometric exercise may assist volleyball players in enhancing both abilities. The capacity of players to utilise and maximize the elastic and neural characteristics of the SSC following plyometric training may significantly improve sprint performance, which demands an explosive concentric and SSC force generation in the lower limb muscles. Additionally, plyometric exercise incorporating various neuromuscular adaptations (such as enhanced intermuscular coordination and firing frequencies) may support agility, which is multifactorial and very complex, increasing the pace of force creation and power output.

Plyometric training's effects on volleyball players of both sexes' agility were examined in two trials. In a research that lasted eight weeks and included young ladies under the age of 15, it was shown that performance in a shuttle run had greatly improved. In a longer intervention with young adult men, it was also discovered that participants' agility in a 50 m shuttle run was significantly improved. This was demonstrated by the fact that the times to complete the shuttle run decreased from 14.15 to 12.86 s for participants wearing a weighted vest and from 14.51 to 13.97 s for participants not wearing a weighted vest. The results of both investigations supported the idea that plyometric exercise improves agility. Through an increase in muscle power production and movement effectiveness, plyometric exercise may help shorten ground contact durations.

Conclusions

The bulk of the studies examined young players, and the majority of them exclusively looked at female players. However, it was discovered that there was a paucity of data about the players' development, which could have affected how well the programs worked. The more studies and bigger gains as compared to horizontal leaps seem to be explained by the similarities between the motions used in training programs and the vertical jump test. Future research should, however, provide additional details regarding the characteristics of the training programs. Studies have also shown that the SSC, a common plyometric training component, promotes the required stimulation to increase both strength and flexibility. This fact is supported by improvements in coordination caused by the firing of a large muscle unit in the first case and by the necessary lengthening movement in the second.

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