COMPARISON OF PLYOMETRIC JUMP TRAINING VERSUS POST ACTIVATION POTENTIATION FOR IMPROVING VERTICAL JUMP PERFORMANCE IN COLLEGE GOING VOLLEY BALL PLAYERS

[1]Duvvuru Gowtham kumar, [2]Pilladi Chaturvedi, [3]Dr. Patchava Apparao, [4]Dr. Ch. Ganapathi Swamy

[1]Post Graduate Student MPT (Sports Medicine), [2]Associate professor, [3]principal, [4]Associate professor of biostatistics
[1,2,3]Department of physiotherapy, GSL College of Physiotherapy, rajamahendravaram, Andhra Pradesh, India.
[4]Department of Community Medicine, GSL Medical College, rajamahendravaram, Andhra Pradesh, India.

Corresponding Author: Duvvuru Gowtham kumar

Abstract-
Background and objective: The lack of vertical jump performance is the main discourage one to the volleyball players to block are to strike the ball in volleyball game. the vertical jump is also important for defensive play in volleyball, as players must be able to jump up and dig balls that are hit hard and high. The main objective of the study was to find out the effects of plyometric jump training versus post activation potentiation on vertical jump performance in college going volley ball players
Methods: Randomized control trail. In this study, 85 subjects were screened between the age group of 18 -25 years both male and females included and according to inclusion and exclusion we included 60 persons randomly allocated into two groups. Each group containing 30 subjects. Group-A received plyometric jump training and Group-B received post activation potentiation training. Subjects received intervention of 3 session per week for a period of 6 weeks. The outcome measures of this intervention were measured in term of Sergeant jump test for vertical jump measurement.
Results: Independent t-test was used to compare the mean significance difference between continuous variables. Paired t-test was used to assess the statistical difference between pre-test and post-test scores p value of (0.0001). Statistical analysis of the data revealed that within the group comparison, both groups showed significant improvement in all parameters. Whereas, in between the group's comparison plyometric jump training group showed better improvement.
Conclusion: After six weeks of training both GROUP A and GROUP B showed significant improvement in vertical jump performance in college going volley ball players. However, Group-A who received plyometric jump training showed more improvement when compared to post activation potentiation in vertical jump performance.

Keywords: **plyometric jump training, post activation potentiation training, Sergeant jump test, vertical jump performance, College going volleyball players.**

INTRODUCTION

Volleyball is one of the most popular sports in the world and is played by 200 million people worldwide[1], it is characterized by short and explosive movements such as jumping, landing, blocking and spiking the ball[2]. Volleyball is a team sport characterized by periods of short duration (3–9 sec), high-intensity activities, interspersed with relatively long periods (10- 20 sec) of recovery time[3]. Although the actions performed by players may vary in terms of their individual roles[4].

In the sport of volleyball, two teams of twelve players each compete on a court that is divided by a net. The goal of the game is to send the ball over the net to land on the court of the opposition while preventing them from making the same attempt. To recover the ball, the team has three hits or contacts. Explosive power, sometimes referred to as vertical leap ability, is a prerequisite for playing volleyball. A volleyball match can last up to 90 minutes if five sets are played, during which time a player can execute 250–300movements that are mostly powered by their leg muscles' explosive strength[5].

It has been shown that spike leaps and block plays account for the majority of volleyballinjuries[6]. According to a recent study, 86.5% of anterior cruciate ligament (ACL) injuriesduring volleyball practice are seen in non-contact scenarios,

and 75% of ACL injuries occur during the jump-landing phase[7].
One of the most important skills for both sexes to practice volleyball well is leaping[8].A vital component of explosive performance in many sports, including basketball rebounding, volleyball spiking, and high leaping, is vertical jumping. Jumping is a multi-jointed, intricate movement that requires a large output of power in addition to force generation. The importance of the maximal rate of force generation in enhancing explosive leaping performance has been highlighted by a number of researches.

The force generated by the hip, knee, and ankle joints, the rate of force development (muscle power) produced by these muscles, and the neural coordination of the movement are among the several variables that have been shown to be significant determinants of vertical jumping performance. It appears that a subject's strength level prior to the start of the training program determines how much their ability to jump can be improved[9].
The term "plyometric" is currently used to describe exercises that originated in "Europe,"where they were originally referred to as "jumping training." The rise in popularity of this jump training in the early 1970s coincided with the rise of East European athletes toprominence in international sports.
A type of exercise called plyometrics is intended to increase the intensity or explosive power in specific muscle groups. This type of training is meant to boost a boxer's punch power or a basketball or volleyball player's jumping force. By taking advantage of the muscle cycles' lengthening and shortening, it boosts muscle power. This type of exercise typically begins with a quick stretch, or the eccentric phase, of a muscle, followed by a quick contraction, or the concentric phase, of the same muscle. Plyometric exercises include burpees, clap push-ups, jumping ropes, and jumping jacks[10].
There are several variations of plyometric exercises based on the objectives of a trainingregimen. The countermovement jump (CMJ), drop jump (DJ), and squat jump (SJ) are common plyometric exercises. These workouts can be used separately or in combinationas part of a training regimen. Moreover, plyometric exercises can be done at different intensities, from high unilateral intensity drills to low-intensity double-leg hops. Body-weight jumping exercises like Drop jump, Counter movement jump, alternate-leg bounding, hopping, and other stretch-shortening cycle (SSC) jumping exercises are all part of plyometric training. stretch-shortening cycle actions are what distinguish these exercises[11,12,13,14].

Plyometric exercise enhances muscular strength, power, coordination, and sports performance. Plyometric training has been shown to increase vertical jump height in numerous studies. Plyometric training's effects can vary based on a number of subjects' characteristics, including training experience, gender, age, level of sport participation, and familiarity with the technique.
Training volume and program length appear to be additional factors that influence the efficacy of plyometric training. Numerous combinations of duration, intensity, andvolume characteristics have been used in research studies[15].
A contraction that follows conditioning results in an increase in muscle performance known as post-activation potentiation, or PAP. A maximal voluntary contraction, an evoked tetanic contraction (post tetanic potentiation), or a sequence of evoked twitches could all be the conditioning contraction[16].
Skeletal muscle's contractile response is influenced by its past contractile experiences. Weariness from repetitive contractile stimulation causes performance to deteriorate. Nevertheless, post activation potentiation, or PAP, is also elicited concurrently with the realization of fatigue. Post activation potentiation is the term used to describe the phenomenon whereby contractile history leads to an increase in acute muscle force output. This is the foundation for the concept of "complex training." It has been suggested that intense resistance training before explosive movements could improve them. For instance, improving vertical jumping performance can be achieved by performing a series of high-intensity squats before performing a vertical or horizontal jump[17].
Post activation potentiation aims to increase muscle power and strength in response to a conditioning exercise that came before it, such as sets of loaded (80–90%) resistance exercises using free weights[18]. An immediate increase in muscle performance is linked to a physiological phenomenon called post activation potentiation[19].

However, there are no comparative studies done to determine which exercises is more effective in vertical jump performance and preventing injuries during vertical jumping. Therefore, the purpose of this study is to evaluate the effect of plyometric jump training and post activation potentiation on college going volleyball players.

REVIEW OF LITERATURE

Hamed, sama et al (2023) had done a study on "The impact of post activation potentiation during warming up using vertical drop jump on some of the physical variables for female volleyball players" The current study sought to determine the effect of post activation potentiation during warm-up using the vertical drop jump on both lower extremity muscular ability and reactive agility in female volleyball players. The study sample consisted of 15 female Aviation Club first-team players (age: 21,96 1.80 years), (body mass:68.96 8,13 kg), and (height: 172,35 4, 39 m). The experiment al method was used with a measurement design (pre- and post-test) and a single experimental group. The vertical drop jump test with the Axon jump was used to assess lower extremity muscular ability, and the test (9, 3, 6, 3, 9) was used to assess reactive agility. The measurements were conducted in two stages: the first part was the pre-test, in which the

valuesof the two tests under study were determined. The second part was the post-test, which wasperformed after applying the post activation potentiation in 5 m and 48 hours after the pre-test. The results showed that positive sharp muscle activation improved lower extremity muscular capacity values as represented by jump height, as well as improved speed in the interactive agility test.

International Journal of Sports Science and Arts 22(1):31-41 February 2023

Abdurrahman Boyaci, Tuba Kizilet et al (2023) had done a study on "Acute effects of cluster set and traditional set post activation potentiation protocols on vertical jump performance" The purpose of this study was to look into the acute effects of different post- activation potential (PAP) protocols on female athletes' Countermovement Jump (CMJ) performance. Twelve elite female taekwondo athletes (age 15.17.18 years, height168cm, and body weight 55.5 kg) volunteered to participate in the study. The research group received resistance training using the traditional set (1 Repetition maximum 75% x 3 sets x 12 repetitions and 180 s rest between sets) and clusterset (1 Repetition maximum 75%×3 sets × 4+4+4(total 12) repetitions, 30 s rest between sets and 180 s rest between sets). Countermovement Jump test results were recorded for 30 seconds, 4 minutes, and 8 minutes before and after both post activation potentiation protocols. For the pre-posttest comparison, a paired sample t-test was used. There was a statistically significant difference between the Countermovement Jump pre-test and the Countermovement Jump 4 min test in the traditional set structure. A statistically significant difference was found in the cluster set structure between Countermovement Jump pre-test and Countermovement Jump 30sec, Countermovement Jump pre-test and Countermovement Jump 4 min, and Countermovement Jump pre-test and Countermovement Jump 8 min. these results are showing that there is a statistically significant improvement in the players before and after the training.

European Journal of Physical Education and Sport Science - Volume 9 Issue 6| 2023

Ahmadi, M.; Nobari, H.; Ramirez-Campillo et al (2021) had done a study on "A. Effects of Plyometric Jump Training in Sand or Rigid Surface on Jump-Related Biomechanical Variables and Physical Fitness in Female Volleyball Players" The purpose of this study is to see how 8 weeks of plyometric jump training (PJT) on sand or a rigid court surface affects jump-related biomechanical variables and physical fitness in female indoor volleyball players. Methods: Seventeen participants were randomly assigned toone of two groups: sand surface (SsG, n = 8) or rigid surface (RsG, n = 9). Both groups went through the same indoor volleyball training routines. Participants were evaluated for jump-related biomechanical variables (countermovement jump (CMJ) RSI; drop jump (DJ) reactive strength index (RSI); spike jump height; countermovement jump height: countermovement jump rate of force development; countermovement jump velocity at take-off; Drop jump height and countermovement jump peak force), 20 m linear sprint time, t test for change-of-direction sprint (CODs) time, Wingate test peak force, and power, cardiorespiratory endurance, and one- repetition maximum (1RM) for leg presses. A two-way mixed analysis of variance (group time) revealed a significant grouptime interaction between drop jump height ($p = 0.035$) and countermovement jump peak force ($p = 0.032$) in favor of rigid surface and sand surface. There was also a significant interaction for cardiorespiratory endurance ($p = 0.01$) and 1RM ($p = 0.002$), both of which favored the Sand surface. The result's showed that a highly significant improvement in pre and post values of the measurements.

International Journal of Environmental Research and Public Health 2021, 18(24), 13093

RODRIGO RAMIREZ et al (2020) had done a study on "Effects of plyometric jump training on vertical jump height of volleyball players: systemic review with meta- analysis of randomized controlled trial" The purpose of this meta-analysis was to compare the effects of plyometric jump training (PJT) on volleyball players' verticaljump height (VJH) to those observed in a matched control group. They only used healthyvolleyball players with no age or gender restrictions. Two authors independently extracted data from the included studies. 14 studies were meta-analyzed from 7,081 records. Vertical jump height had a moderate Cohen's d effect size (ES = 0.82, p =0.001), moderate heterogeneity ($I2 = 34.4\%$, $p = 0.09$), and no publication bias (Egger's test, $p = 0.59$). To summarize, plyometric jump training appears to be effective inimproving volleyball players' Vertical jump height. Both male and female volleyball players of various ages can improve their Vertical jump height with relatively low-cost programs. He had concluded that the results had improved statistically in volley ball player.

Journal of Sports Science and Medicine (2020) 19, 489-4

AARON D. PIPER, DUSTIN P et al (2020) had done a study on "Comparison of Post-Activation Potentiating Stimuli on Jump and Sprint Performance" — The purpose of this study was to see how different potentiating stimuli affected jump and sprint performance in 13 resistances trained, college-aged men and women. After determining their back squat 1 repetition max, participants returned for testing on separate days to complete one of four interventions (dynamic resistance, weighted plyometric, isometric, or control) in a randomized order. A standardized warmup was followed by a baseline countermovement jump (CMJ) and a 20-metre sprint. After warming up and taking baseline measurements, subjects chose one of the four experimental conditions. Counter movement jump and 20m sprint measurements were repeated at 0-second intervals, 4, 8, 12, 16, and 20 minutes. Results showed significantly faster 0-20m sprint times ($p < .05$) at 4, 8, 12, 16, and 20-minute time points compared to the baseline 20-second time intervals. The squat, plyometric, and isometric interventions resulted in significantly faster 0-20m sprint times ($p < .05$) compared to the control group at 4-minutes, 8-minutes, 12-16-minutes, and 20-minutes. These findings suggest that all Post activation

potentiation exercises can improve the jump performance in the players. which also showed by improving the post values of the results in height.

International Journal of Exercise Science 13(4): 539-553, 2020

GAHREMAN D et al (2020) he had done a study on "Post activation potentiation effect of two lower body resistance exercises on repeated jump performance measures" The effects of combining squat and deadlift exercises on subsequent repeated jump performance were investigated in this study. During the first week, participants completed two familiarization sessions to practice the repeated jump protocol and to perform a one repetition maximum (1RM) test for back squat (BSq) and deadlift (DL) exercises. During weeks 2-4, the order of the Post activation potentiation conditions (back squat, deadlift,or a combination of back squat and deadlift [back squat + deadlift]) was assigned at random, and all participants completed each Post activation potentiation condition in the order assigned, separated by one week. The repeated jump protocols were performed eightminutes after each of the conditioning activities. From each repeated jump protocol, poweroutputs, flight time, contact time, and reactive strength index were recorded. Measures were taken. Inferential statistics and effect size (ES) calculations were used to comparethe back squat, deadlift, and back squat + deadlift sessions, as well as the sessions that produced the best power output (BEST) with control condition. The back squat condition produced significantly more power than the control condition (p0.05, Effect Size = 1.07), but no differences were found in the other conditioning activities. Furthermore, the BEST condition's power output, flight time, and reactive strength index were significantly higher than the control condition (p0.05, ES = 0.97-1.47). According to the findings, post activation potentiation was the best conditioning activity for increasing power output during a repeated jump protocol. Greater improvement during the condition,on the other hand, suggests that the type of conditioning activity should be considered on an individual basis.

Biology of Sport, Vol. 37 No2, 2020

Turgut, Elif; Cinar-Medeni, Colakoglu, Filiz; Baltaci, Gul et al (2019) had done a study on "Ballistic Six Upper-Extremity Plyometric Training for the Pediatric Volleyball Players" The goal of this study was to see how a 12-week Ballistic Six upper- extremity plyometric training program affected upper-body explosive power, endurance, and reaction time in pediatric overhead athletes. The study included twenty-eight female pediatric volleyball players. The participants were randomly assigned to one of two study groups: intervention (upper-extremity plyometrictraining in addition to volley ball training; n = 14) or control (only volleyball training; n =14). All participants were tested for upper-body power, strength and endurance, and reaction time before and after a 12-week training program. An analysis of variance test was used for statistical comparison Comparisons revealed that the Ballistic Six upper- body plyometric training program resulted in more improvements after a 12-week training program. When compared to control training, there were greater improvements in overhead medicine ball throwing distance and push- up performance, as well as greater improvements in nonthrowing arm reaction time. Furthermore, a 12-week training program was found to be effective in improving reaction time, change of direction and jump performance in the group A who received plyometric training.

Journal of Strength and Conditioning Research 33(5): p 1305-1310, May 2019.

Sarica S et al (2019) had done a study on "Analyzing the effects of post activation potentiation on vertical jump height in volleyball players" The study's goal was to determine the effect of post activation potentiation (PAP) on jump performance in volleyball players and compare it to the effects of PAP in males and females. Forty volleyball players were randomly assigned to one of two groups: control or experimental. The experimental group performed a post activation potentiation protocol consisting of three sets of ten repetitions of back squats at 50% of 10 repetition maximum, 75% of 10 repetition maximum, and 100% of 10 repetition maximum. Subjects performed three consecutive vertical jumps at the end of the last set of squats. Prior to assessing jump performance, subjects in the control group only warmed up for 10 minutes. The results revealed a highly significant difference (p=0.0002) between pre and post values of vertical jump height in males, as well as a significant difference (p=0.0008) in females.

European Journal of Physical Education and Sport Samor - Volume 5 | Issue 10 | 2019

Ana Filipa Silva , Filipe Manuel Clemente et al (2019) had done a study on "The Effect of Plyometric Training in Volleyball Players: The goal of a Systematic Review was to examine the effects of plyometric training on volleyball players' performance. A systematic search was conducted using PubMed, Medline, Scopus, Academic Search Complete and Web Science in accordance with the preferred reporting items for systematic reviews and meta- analyses (PRISMA) guidelines for articles published no later than December 2018. For the included sample, no criteria were imposed. The search concentrated on interventional studies in which athletes participated in a plyometric program. Another five articles were added to the 1831 found through other sources. Duplicate files were removed, and titles and abstracts were screened, leaving 21 studies forin-depth analysis. The vertical jump (15 studies) was found to be the most studied ability in plyometric training interventions. Strength (four studies), horizontal jump (four studies), flexibility (four studies), and agility/speed (three studies) were the next most studied. Furthermore, it was discovered that female athletes under the age of 18 were the most studied. Plyometric training appears to improve vertical jump performance, strength, horizontal jump performance, flexibility, and agility/speed in volleyball players, according to the studies included.

International Journal of Environmental Research and Public Health 2019, 16, 2960

DARIUSZ, KRZYSZTOF et al (2017) had done a study on "Effects of volleyball plyometric intervention program on vertical jump ability in male volleyball players" The purpose of this study was to look into the impact of a 6-week plyometric exercise training program on the development of lower limb explosive power as measured by vertical jumping ability in university-level volleyball players. The study included nine male volleyball players from the AWF Wroclaw University Sports Club, each with at least five years of training and competition experience. The program included several bounds, hops, and jumps in vertical, horizontal, and mixed directions. Throughout the program, a progressive overload of plyometric interventions was used. Lower limb explosive power, expressed as vertical jumping ability, was developed and tested. The jumping ability was assessed using the Opto Jump system to perform five different types of maximum-effort vertical jumps. Additionally, once per week, the heart rate was recorded using a Polar RS300X GPS heart rate monitor (Finland). RESULTS: The only significant correlations were found between the squat jump and the number of jumps, as well as the counter movement jump and heart rate. In conclusion from a practical standpoint, the improvement that was noticed that 6 weeks appears to be the optimal period for volleyball players to adapt to significant increased training load for vertical jump performance.

The Journal of Sports Medicine and Physical Fitness 2017 Sep 05

Whitney D Leyva, David C Archer, Andrew J Galpin et al (2016) had done a study on "comparison of dead lift versus back squat post activation potentiation on vertical jump" The goal of this study was to see how back squats and hex bar deadlifts affected vertical jump performance. Twenty resistance-trained men (age =22.15 2.66 years, height = 178.10 7.20 cm, weight = 78.91 8.67 kg) volunteered to participate and performed three pre-countermovement jumps followed by three repetitionsof back squat or hex bar deadlift at 85% of their one-repetition max. Subjects jumped with an arm swing on a force plate to perform the countermovement jump. The back squat was done with a standard barbell in a power rack with a safety squat device to ensure a thigh parallel position, while the hex bar deadlift was done with the low handles and no straps. After the lifts, the subjects rested for 8 minutes before performing three post-countermovement jumps. The control condition included three pre-countermovement jumps, eight minutes of standing rest, and three post-countermovement jumps. These results are saying that there is a statistically significant increase in both groups jump performance for jump height.

Gavin Journal of Orthopedic Research and Therapy Volume 2016; Pages 5

Ozkan, **Fatma**, **Celil et al (2016)** had done a study on "Effect of an eight-week plyometric training on different surfaceson the jumping performance of male volleyball players" The purpose of this study was to see if 8 weeks of plyometric training on a wooden or synthetic surface affected volleyball players' jump performance. This study included 36 male volleyball players ranging in age from 18 to 24. All participants were randomly assigned to one of three groups: wooden surface (n:12), synthetic surface (n:12), and control group (n:12). Wooden and synthetic surface experimental training groups worked three days a week for eight weeks. The training program includes 20 different plyometric exercise drills, which are performed over an 8-week period. All tests were completed by the subjects in three groups before and after eightweeks of plyometric training. After 8 weeks of plyometric training on the vertical and horizontal jumps, a statistically significant difference was discovered. The experimental group won the horizontal jump parameters. According to these findings, plyometric training is effective on volleyball players' jump performance.

Journal of Physical Education and Sport 16(1):162-169 MARCH 2016

ARABATZI F et al (2014) he had done a study on "The post-activation potentiation effect on squat jump performance: age and sex effect" The effects of post-activation potentiation (PAP) on squat jump (SJ) performance and peak rate of force development (RFD peak) in preadolescent (10-12 y), adolescent (14-15 y), and adult (20-25 y) males and females were investigated in this study. All participants performed a squat jump consisting of three 3-second maximal isometric squats with and without prior conditioning stimulus (post-activation potentiation and control protocol, respectively). Before, 20 seconds, and 4 minutes after the conditioning stimulus, jump height and peak rate of force development of the vertical ground reaction force during squat jump were measured. The findings revealed a distinct pattern of age-effect on squat jump performance in both males and females. The peak rate of force development increased significantly with age in both males and females (p 0.05).

Pediatric Exercise Science,2014,26,187-194

Jastrzebski Z, Wnorowski K, Mikolajewski R et al (2014) had done a study on to determine "the effects of a six-week plyometric high and low-intensity training on the explosive power of lower limbs in volleyball players". Material/Methods: The studyincluded 30 volunteers from the Sports Club at Gdansk University of Technology in Gdansk. The participants were divided into two homogeneous groups prior to the experiment. Following a two-week introductory common stage, each group followed a plyometric regime of varying intensity. The findings revealed that a high-intensity program was more effective than a low- intensity program in developing explosive power in volleyball players. Results: The vertical jump with arm swing showed the most significant improvement in the players.

Baltic Journal of Health and Physical Activity 6(2):79-89 JUNE 2014

McCann, Matthew R; Flanagan, Sean P et al (2010) had done a study on "the effects of exercise selection and rest interval on post activation potentiation of vertical jump performance" The goal of this study was to see if a power

exercise caused more post activation potentiation than a strength exercise, if a 4- or 5-minute rest interval caused more post activation potentiation, how much post activation potentiation was an individual phenomenon, and how post activation potentiation affected the ground reaction force (GRF) during a vertical jump (VJ). Subjects included 16 volleyball players from a Division I university (8 men and 8 women). Here all the Participants were instructed to perform a pre-exercise height countermovement jump. Following the Vertical Jump, subjects performed 5 repetitions of either the back squat or the midthigh hang clean with a load equal to their 5-repetition maximum (5RM). Countermovement jumps were completed 4 or 5 minutes after the -repetition maximum resistance exercise. a back squat or a clean hang. The ground reaction force was measured with a force platform embedded in the ground, and the vertical jump height was measured witha Vertical jump apparatus. A factorial analysis of variance with repeated measures was used to analyze the data. There was no consistent rest interval or exercise that produced the greatest increase in Vertical Jump height for all subjects, and there were no obvious differences based on gender. The condition that resulted in the greatest increase in Vertical Jump height for each individual resulted in a 5.7% increase on average.

Journal of Strength and Conditioning Research 24(5): p 1285-1291, May 2010.

R SOUNDARA RAJAN et al (2010) had done a study on "Effects of plyometric training on the development the vertical jump performance in volleyball players" The current study looked at the impact of plyometric training on volleyball players' vertical jump development. The study included 30 male volleyball players aged 18 to 25 from PSG College of Arts & Science in Coimbatore. Participants were randomly assigned to Group I for plyometric training and Group II for control. For six weeks, the plyometric training group performed a set of plyometric exercises designed by the researcher twice aweek. The control group was allowed to play their game but received no treatment. For the purposes of this study, two volleyball vertical jump evaluation tests were validated: the block jump and the spike jump. Paired t-tests were used to test the effect of treatment groups individually between pre and post-tests, of all groups, on variables used in the current study. The study's findings show that there was a statistically significant difference in 0.05 levels.

Journal of physical Education and Sport Vol 28, no 3, September, 2010

Eduardo saez saez de villarreal et al (2009) had done a study on "Determining variables of plyometric training for improving vertical jump height performance: a meta- analysis" To investigate the role of various factors on the effects of plyometrics on vertical jump height performance, a meta-analysis of 56 studies with a total of 225 effect sizes (ESs) was performed." The analysis included studies that a) used plyometric programs for lower- limb muscles, b) used true experimental designs and valid and reliable measurements, and c) included enough data to calculate ESs. Subjects with more athletic experience improved their vertical jump height performance more (p 0.01). Plyometric work benefits subjects in either good or bad physical condition equally (p0.05), though men tend to achieve better power results than women after plyometric training (p 0.05). In terms of performance variables, training volumes of more than 10 weeks and more than 20 sessions of high- intensity programs (with more than 50 jumps per session) seemed to improve the players performance and also statistically significantly greater improvement in performance (p 0.05).

journal of Strength and Conditioning Research 2009, VOLUME 23 23(2): p 495-506

SHAJI, JOHN T. AND SALUJA ISHA. et al (2009) he had done a study on "Comparative analysis of plyometric training program and dynamic stretching on vertical jump and agility in male collegiate basketball player" The study's goal was to compare and contrast the individuals and combined effects of plyometric training and dynamic stretching on vertical jump and agility. 45 healthy male collegiate basketball players between the ages of18 and 25 were included in the study. Prior to beginning the dynamic stretching and plyometric training program, all subjects were tested in vertical jump and agility using the Sergeant Jump test and T-test, respectively. The subjects were then retested after completing a four-week plyometric training program. Here the results had been showed that the group who received plyometric training showed a good improvement in results & there is an significantly improvement present over the players.

Al Ameen Charitable Fund Trust, Bangalore Volume 2, No.1, 2009

GORAN MARKOVIC et al (2007) had done a study on "Does plyometric training improve vertical jump height? A meta-analytical review" This study aimed to determine how plyometric training (PT) affects vertical jump height in healthy individuals. Meta-analyses of randomized and non-randomized controlled trials were conducted to assess the impact of PT on four common vertical jump height tests: squat jump (SJ), countermovement jump (CMJ), countermovement jump with arm swing (CMJA), and drop jump (DJ). We conducted both computerized and manual literature searches to identify studies. A meta-analysis was conducted to compare changes in jump height between plyometric and control groups, with separate analyses for each type of jump. A total of 26 studies produced 13 data points for squat jump, 19 for countermovement jump, 14 for countermovement jump with arm swing, and 7 for drop jump met initial inclusion criteria. The effect of plyometric training on vertical jump height was estimated to be 4.7% (95% CI 1.8–7.6%), 8.7% ,7.5%, and 4.7% for the squat jump, countermovement jump, countermovement jumps with arm swing, and drop jump. The results of plyometric training on vertical jump height were showed a statically significant improvement in players. plyometric training improves vertical jump height by 4.7% on average. These findings support the use of physical therapy to enhance vertical jump performance in individuals.

Br Journals Sports Med 2007; 41:349–355.

GEHRI, DANIEL, RICARD, MARK et al (1998) had done a study on "A comparison of plyometric training techniques for improving vertical jump ability and energy production". This study was conducted to determine which plyometric training technique is most effective for improving vertical jumping ability, positive energy production, and elastic energy utilization. The data were collected before and after 12 weeks of jump training and analyzed using ANOVA. Subjects (N = 28) performed jumps under three testing conditions: squat jump, countermovement jump, and depth jump. They were randomly assigned to one of three groups: control, depth jump training, or countermovement jump training. Both training groups showed significant increases in vertical jump height after completing the 12-week program. The depth jumpers significantly increased their vertical jump height in all three jumps. None of the training methods improved the use of elastic energy. In activities involving dynamic stretch-shorten cycles, drop jump training was superior to countermovement jumping. This study supports the strength and conditioning professional's recommendation to incorporate plyometric depth jump training into the athlete's overall program to improve vertical jumping ability and concentric contraction performance.

Journal of Strength and Conditioning Research 12(2): p 85-89, May 1998.

MATERIALS AND METHODS

STUDY DESIGN: Randomized control trial design

ETHICAL CLEARANCE AND INFORMED CONSENT: The study protocol was approved by the Ethical Committee of GSL Medical College & General Hospital (Annexure- I). The investigator explained the purpose of the study and given the subject information sheet; The participants were requested to provide their consent to participation in the study (Annexure-II). All the participants signed the informed consent and the rights of the included participants have been secured.

STUDY POPULATION: College going volleyball players who were willing to participate in the study

STUDY SETTING: the study was conducted in the sports arena of GSL MEDICAL COLLEGE, RAJAMAHENDRAVARAM, ANDHRA PRADESH, INDIA

STUDY DURATION: Study will be conducted during a period of one year

TREATMENT DURATION: Both the groups received intervention of three session per week for a period of six weeks

STUDY SAMPLING METHOD: simple random sampling

SAMPLE SIZE: A total of 85 participants were screened for eligibility out of 60 collegiate players were recruited and were explained about the process and relevance of the study. Those willing to be voluntarily included in the study received informed consent and were asked to sign the forms. All the participants were consecutively randomized to either plyometric jump training and post activation potentiation with 30 subjects in each group.

GROUPS	NO OF SUBJECTS	INTERVENTION
GROUP A	30	PLYOMETRIC JUMP TRAINING
GROUP B	30	POST ACTIVATION POTENTIATION

MATERIALS USED

1. Measuring inch tape
2. Cones
3. Marker
4. Ball
5. Rods

CRITERIA FOR SAMPLE SELECTION

INCLUSION CRITERIA:

- Subject should be 18 to 25 years.

- The participants had to be physically active in volleyball playing for two years.

- College going students are included in the study
- Both males and female college players are included
- Average jump height for males 30- 50 cm and females 20- 40 cm

EXCLUSION CRITERIA:

- Taking any personal training or gym are excluded
- Participant taking any kind of drug therapy
- subjects with recent surgeries
- ligament injuries
- known cardiovascular and neurological disorders

STUDY TOOLS AND OUTCOME MEASURES

SERGEANT JUMP TEST: used to evaluate the vertical jump performance in the volley ball players

PROCEDUR:

Before the commencement of the study a brief demonstration and instructional videowas given to the participants and made to get familiarized with the experimental procedures to minimize the learning effects during the course of the study. Subjects' performance was tested before and after the 6-week training period. the testing includes assessment of vertical jump performance by the sergeant jump test. each test was taken thrice and the average was obtained for analysis. the subjects were given rest periods between the tests to ensure recovery between measurements. At the baseline assessment the participants age and gender were taken and then the following assessmentwas done. the consort flow chat of the study shows the organization in the terms of subjects screening, random allocation, and analysis then followed by intervention

TESTING PROCEDURE

Equipment:

- A smooth wall with a relatively high ceiling
- A flat, stable floor that provides good traction
- Chalk (different colour than the wall)
- Measuring tape or stick
- Step stool or small ladder

ASSESSMENT PROTOCOL AND ADMINISTRATION:

Describe and demonstrate the procedure after explaining the purpose of the verticaljump assessment. Allow the client a few trial runs before administering the assessment. Tell the client to stand next to a wall, with the inside shoulder of the dominant armabout 6 inches (15 cm) away from the wall. Mark the fingers with chalk, extend theinside arm overhead, and mark the wall to determine the client's standing height. Thismark will then be compared to the highest vertical jump height.

- The client then lowers his arms and, without pausing or taking a step, drops into asquat before exploding upward into a vertical jump.
- The goal of this evaluation is to jump as far as possible from a standing position

Because proper technique is important in achieving maximum jump height,encourage the client to use his or her arms and legs for propulsion.

- At the highest point, the athlete touches the wall with chalk and marks it.
- The vertical distance between the new chalk mark and the starting height is used tocalculate the vertical jump measurement.
- Allow three repetitions and record the highest height on the assessment form.

- Sort the client's performance using the table below[20].

Fig no-1 taking measurement at starting point

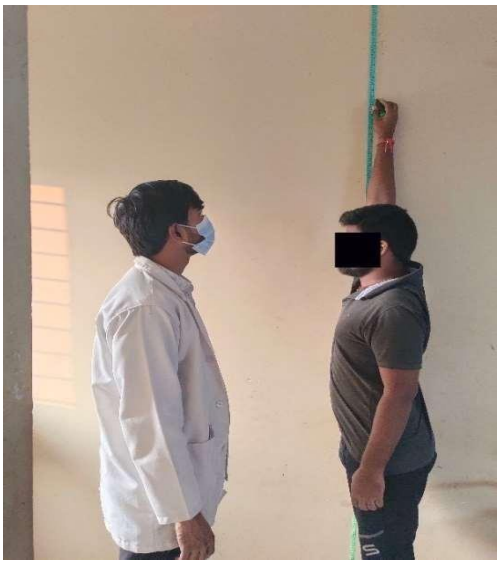
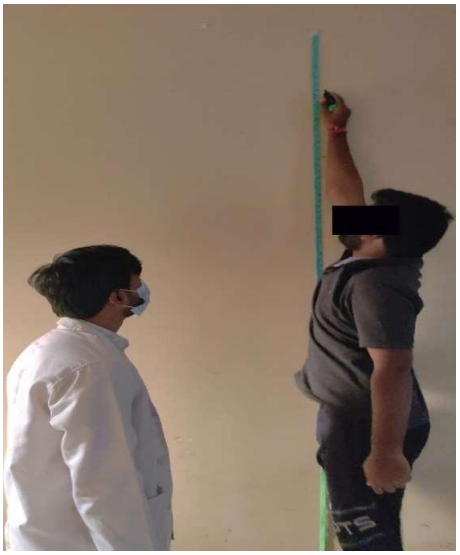


Fig no-2 taking measurements after jumping



INTERVENTION

This is a 6 weeks study which includes plyometric jump training for Group -A and post activation potentiation for Group- B The outcomes were measured by sergeant jump testAll the subjects who are eligible for criteria were allocated randomly into Group-A and Group-B Both groups will follow the standardized warm up protocol consists of 4 min of jogging and 4min of dynamic stretching exercises before the intervention. Afterward they will rest for 10 min. After resting period, the subjects will receive their respective interventions.

GROUP – A

PLYOMETRIC JUMP TRAINING

the subjects in the group A will receive plyometric exercises. In the plyometric training the exercises induced are side to side ankle hops, standing jump reach, front cone hops, split squat jump, standing long jump, lateral jump over barrier, double leg hops will be performed.

S. No	DRILL	START	ACTION
1	Side to side anklehops	Place your feet shoulder-width apart and maintain a vertical posturefor your body.	Make a two-to three-foot leap from side toside with both feet; the movement should come from the ankles. Land on both feet simultaneously, maintaining a shoulder- width distance between them.
2	Standing jump and reach	Stand with your feet shoulder- width apart	Squat slightly and explode upward toward atarget. Do not take a step before jumping.
3	Front cone hops	Standing at theend of the barrier line, space your feet shoulder-widthapart.	Jump over each barrier, keeping your feetshoulder-width apart and landing on bothfeet at the same time. Use a double arm swing and try to spend less time on the ground between each barrier.

4	Splitsquatjump	Step the front leg 90 degreesat the hip and knee, and spread the feetwide apart from front toback.	Jump up, using your arms to help you lift, and maintain the split squat position. Return to your starting position and immediately repeat the jump.
5	Standing long jump	With your feet shoulder-width apart, adopt a semi-squat position.	Jump as far forward as possible with a largearm swing and a counter-movement (flexing) of the legs.
6	Lateral jump over barrier	Stand next tothe item that needs to be removed.	Jump vertically but push sideways off theground, then raise your knees to jump sideways over the Barrier.
7.	Double leg hops	With your feet shoulder-width apart, stand.	Squat down and leap as far forward as youcan. Jump forward again as soon as you touchdown. Use quick double-arm swings andshort landings.

Each exercise will be performed in 2 sets, each set contains 4 repetitions of each exercise. In between each exercise 2 minutes rest period will be given. The treatment duration will be given 40 min per session, 3 days a week for 6 weeks. In the preparation stage (1-2 weeks) the intensity will be of 50% and later weeks treatment goes on, the intensity will be gradually increased.

Players are given proper instruction and that the exercise were performed under the Supervision of the physiotherapist only[21,22]

Fig.no. 3 – Therapist observes as the player performs side - to – hops

Fig.no. 4 – Player performing standing jump and reach test(player uses momentum to reach as high as possible)

Fig.no. 5 – Player performing front cone hops exercise

Fig.no. 6 – Player performing splits quat jump

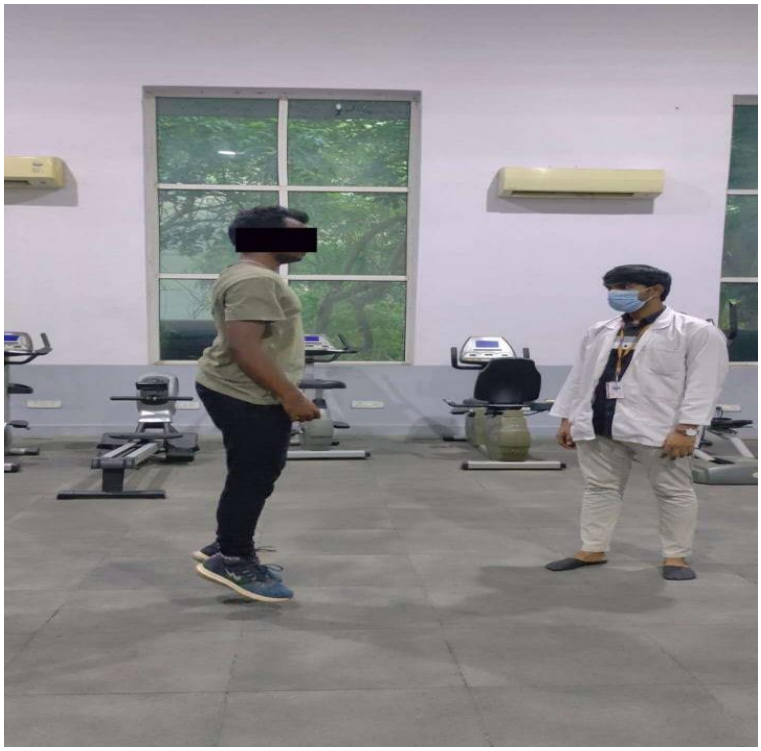


Fig. no. 7- Player performing standing long jump

Fig. no. 8- Player performing lateral jump over barrier

Fig. no. 9- Player performing double leg hops

Group-B

POST ACTIVATION POTENTIATION

The subjects in the group-B will receive post activation potentiation. Before starting the post activation potentiation. The interventionin the post activation potentiation, the subjects will perform the isometric half squats of 3seconds each with the knee joint angle set at 90 degrees 2 sets with 4 RM. In between the 2 sets 2 minutes of rest will be given to the subject. After completion of isometric half squats exercises,9 min active rest will be given to the subjects and then 10 lunges and 10 side shuffles and 10-line hops with 10 a- skips and 10 broad jumps, 10 karaoke with 2 sets of each exercise and 2 min rest for each set after that 6 repetitions of the vertical jump will be performed. The intensity will be 50% during the first two weeks ofthe preparatory phase and gradually rise as the treatment continues[23,24].

S. No	DRILL	START	ACTION
1.	Isometric half squats	Stand with your feet shoulder-width apart and maintain a vertical posture for your body.	Here the player performs the squatting position bykeeping the both handsin90 degrees position
2.	Lunges exercise	Stand with your feet hip-widthapart. Step forward longer than a walking stride so one leg is ahead of your torso and the other is behind.	By keeping the both over the pelvis and Forword bending with keeping one leg and another leg in front with90 degrees flexion of knee and hip
3.	Side shuffles	Stand with your feet slightly wider than hip-width apart, hips and knees bent back, and toes pointed at the front.	bending over to the one and again to the oppositeside with touching the lateral side of the bending side limb
4.	Line hops	Stand next to the line, with your feet hip-width apart. Yourtoes should be pointing straightahead, and the line should be on your left or right side. Bend your knees slightly and lean your body forward a bit.	Here the player has to jump from one side to another sidewith middle bar rod
5.	A- skips	Begin by standing with feet hip-distance apart, look straight a head, and keep your upper body straight.	Raise your left leg to hip height while skipping on theball of your right foot.

6.	Broad jump	Stand with your feet shoulder-width apart. Arms up in the air. Keeping the toes point straight towards jumping side	Begin exercise by swingingyour arms back behind yourbody as you bend your knees and push your hips back Swing arms forward asyou drive your feet into the ground, push hips forward, and explode forward off the ground.
7.	Karaoke	Keeping the foot and shoulder apart straight the hip in straightfor ready to move into the position	Cross your right leg in front ofyour left leg and keep your arms outside. Step open and outward to the side of your leftfoot. Cross your right leg from the back of your left foot. Keep moving sideways and repeat the motion in the opposite direction.

Fig.no.10-player performing isometric half squat

Fig.no.11-player performing lunges exercises

Fig.no. 12-player performing side shuffles

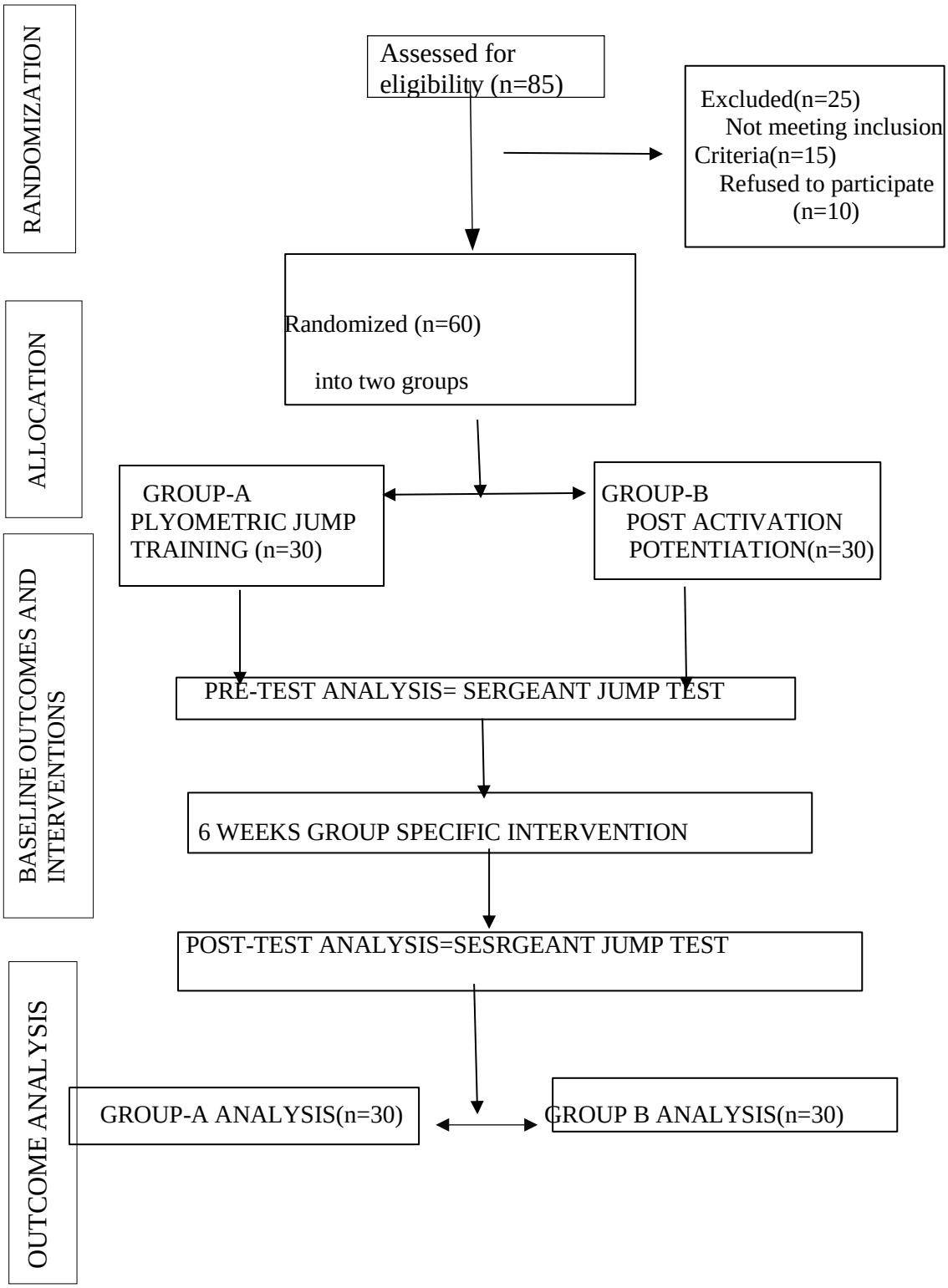
Fig.no-13-player performing line hops

Fig.no-14 player performing a- skips exercise

Fig.no-15 player performing broad jump

Fig.no-16 here player performing karaoke exercise

FLOWCHART


RANDOMIZATION
Assessed for eligibility (n=85)
Excluded(n=25)
Not meeting inclusion Criteria(n=15)
Refused to participate (n=10)
ALLOCATION
Randomized (n=60)
into two groups
GROUP-A
PLYOMETRIC JUMP TRAINING (n=30)
GROUP-B
POST ACTIVATION POTENTIATION(n=30)
BASELINE OUTCOMES AND INTERVENTIONS
PRE-TEST ANALYSIS= SERGEANT JUMP TEST
6 WEEKS GROUP SPECIFIC INTERVENTION
POST-TEST ANALYSIS=SESRGEANT JUMP TEST
OUTCOME ANALYSIS
GROUP-A ANALYSIS(n=30)
GROUP B ANALYSIS(n=30)

STATISTICAL ANALYSIS

- All statistical analysis was done by using spss softwareversion21.0 and Microsoft excel-2007. Descriptive data was presented in the form of mean ± standard deviation and means difference percentages were calculated and presented.
- Within the groups paired student "t" test was performed to assess the statistical difference with the group for vertical jump performance from pre- test and post- test values
- Between the groups independent student "t" test was performed to assess the statistically significant difference mean value between the groups for sergeant jump scale for vertical jump performance. For all statistical analysis, $p \leq 0.005$ was considered as statistically significant.

RESULTS

The aim of the study was to find the comparison of the plyometric jump training and post activation potentiation on improving the vertical jump performance in college goingvolleyball players

A total of 85 students were screened for eligibility in that among them 60 students were recruited into the study under the inclusion and the exclusion of the study. All the subjects were under went baseline assessment and included into the subjects were randomized into two groups consisting of 30 players in each group

In this study the training sessions were given for 6 weeks, 60 participants completed training; with 30 subjects completed training in group-A and 30 subjects completed training in group- B

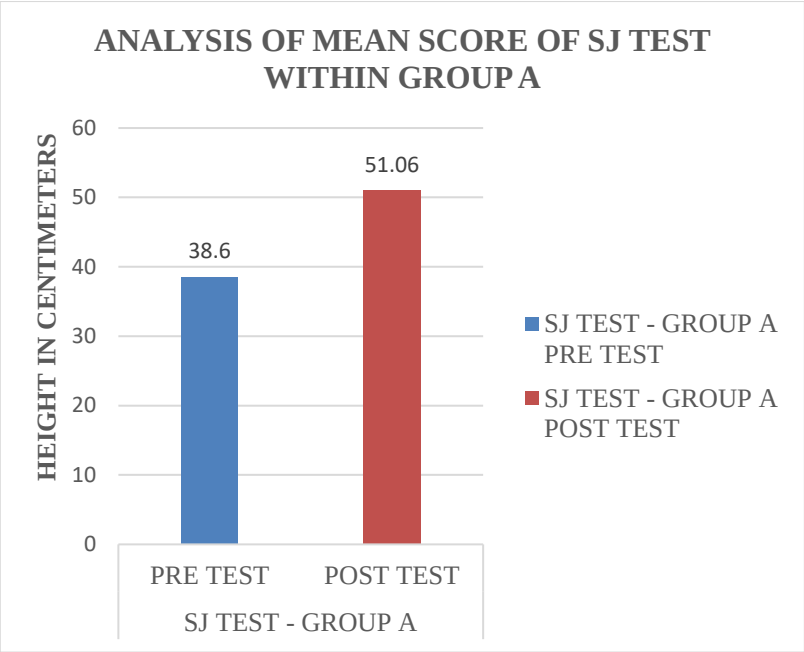
Both the groups showed statistically significant scores in the Sergeant jump test, where p-value was set at $p \leq 0.005$ was significant.

TABLES & GRAPHS

ANALYSING OF MEAN SCORE OF SERGEANT JUMP TEST OF WITHIN GROUP-A

GROUP A		Mean	Std. Deviation	P VALUE	INFERENCES
SERGEANTJUMP TEST	PRE -TEST	38.6	7.337199	0.0001	HIGHLY SIGNIFICANT
	POST-TEST	51.06	7.047143		

TABLE – 1



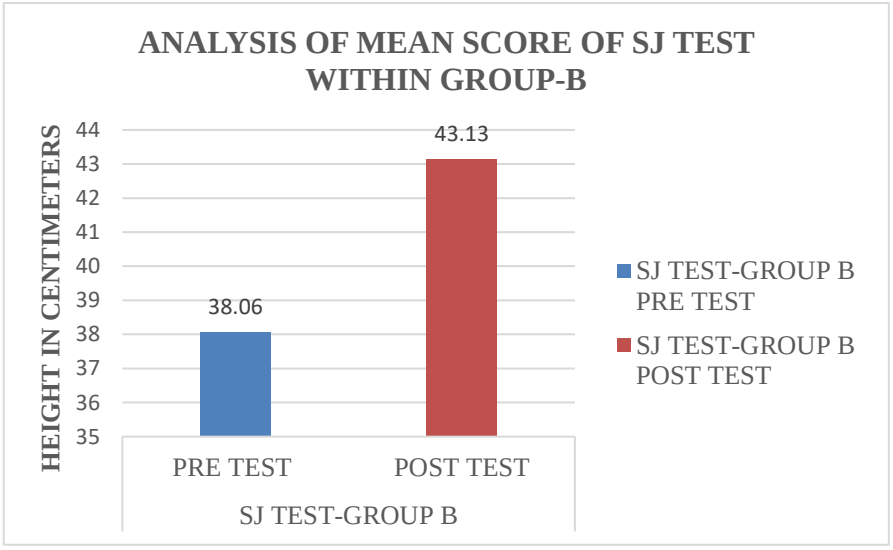
GRAPH -1

RESULTS: The above table and graph shows that mean score of SERGEANT JUMP TEST from pre-testto post-test values within group A were found to be statistically highly significant ($p<0.05$).

ANALYSIS OF MEAN SCORE OF SERGEANT JUMP TEST OF WITHIN GROUP-B

GROUP B		Mean	Std. Deviation	p- value	INFERENCES
SERGEANT JUMPTEST	PRE-TEST	38.06	7.776771	0.0001	HIGHLY SIGNIFICANT
	POST-TEST	43.13	7.99885		

TABLE-2



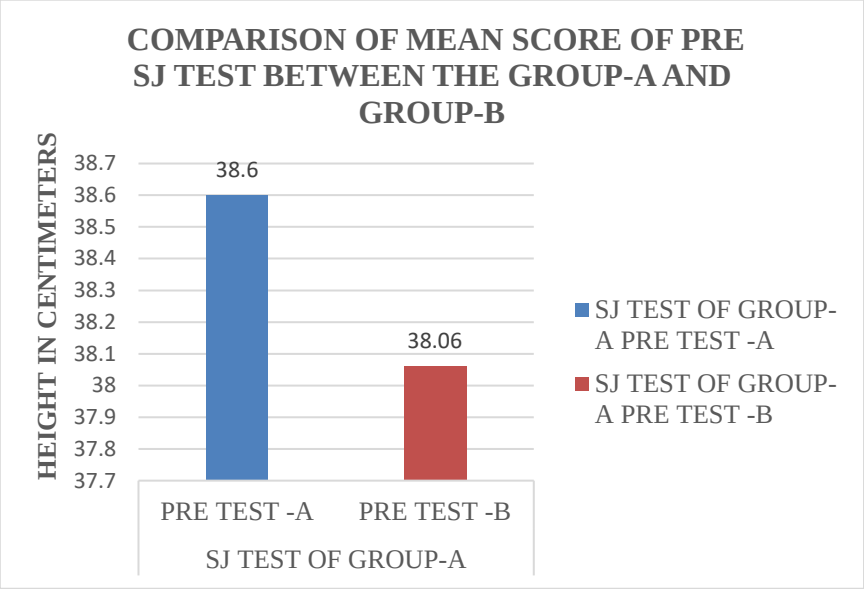
GRAPH– 2

RESULTS: The above table and graph that mean score of SERGEANT JUMP TEST from pre-test and post-test values within Group B were found to be highly significant ($p<0.05$).

COMPARISON OF MEAN SCORE OF SERGEANT JUMP FROM PRE-TEST OF BOTH GROUPS

AGILITY T-TEST		Mean	Std. Deviation	P VALUE	INFERENCES
PRE TEST	GROUP - A	38.6	7.337199	0.7857	INSIGNIFICANT
	GROUP - B	38.06	7.776771		

TABLE-3



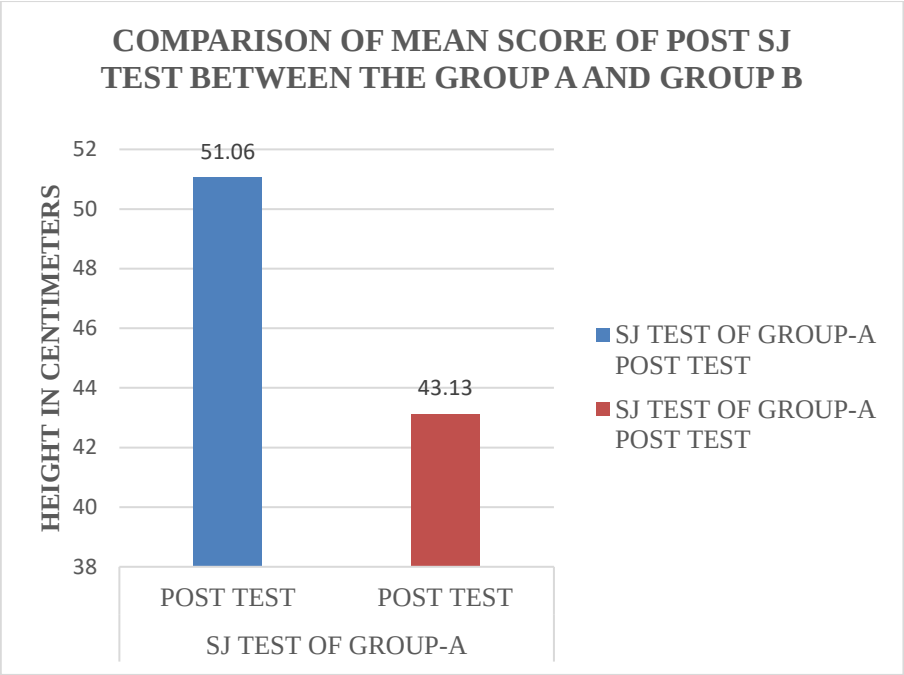
GRAPH-3

RESULTS: The above table and graph shows the mean scores sergeant jump test changesof pre-test between both the groups were found to be insignificant.

COMPARISON OF MEAN SCORE OF SERGEANT JUMP TEST FROM POST-TEST OF BOTH GROUPS

AGILITY T-TEST		Mean	Std. Deviation	P VALUE	INFERENCES
POST - TEST	GROUP - A	51.06	7.047143	0.0001	HIGHLY SIGNIFICANT
	GROUP - B	43.13	7.99885		

Table-4



GRAPH-4

RESULTS: The above table and graph shows the mean scores sergeant jump test post-test between both the groups were found to be highly significant.

DISCUSSION

The main purpose of this study was to evaluate the comparison of plyometric jump training and post activation potentiation training on improvement of vertical jump performance in college going volley ball players. In this study, subjects were assessed forvertical jump height by using the Sergeant jump test outcome measures respectively. sixty subjects were divided into two groups and group-A (n=30) received plyometric jump Training and group-B (n=30) received post activation potentiation Training, who underwent six-week exercise training program for three sessions per week. Assessment was done before and after six weeks training program

By the end of the six weeks training program, the subjects of Group – A who received plyometric jump training had significantly improved results in vertical jump performancewhich showed changes in outcome measures Sergeant jump test Composite mean score($p = 0.0001$). Group – B who received post activation potentiation also showed significant results in Sergeant jump test composite score ($p = 0.0001$).

The results of the study implied that there is a statistically significant improvement in bothplyometric jump Training program and post activation potentiation Training program to effectively bring changes in both outcome measures, Sergeant jump test in college going volley ball players This study hypothesized around the concept that plyometric jump training will be more effective in improving vertical jump performance.

The study is supported by Jastrzebski Z et al who stated that effects of plyometricjump training were improve the vertical jump performance in the female volley ballplayers. Here by using the plyometric jump training exercises to the subjects which improved the power of the muscles which help in the jumping performance in the game they mainly seen the block jump and the spike jump these are the moves which used in during the game play by the help of the plyometric training where he performed depth single leg hops and the jump and reach are showed very much improvement in the power of the muscles in the lower limb. Volleyball players also employ two distinct Block jump techniques: starting from a squat or from an upright position. This could have an impact on how force is generated during a game. A player may jump higher and run faster if their muscles are already fully loaded. The author concluded that plyometric `training improves the performance of the vertical jump of the female volley ball players[25].

In the same way a study done by McCann, Matthew R et al who explained that According to the results of the current investigation, The goal of this study was to see if (a) a power exercise resulted in h igher Post activation potentiation than a strength exercise; (b) a 4- or 5-minute rest interval resulted in higher Post activation potentiation; and (c) if the effect of Post activation potentiation was an increase in peak Ground reaction force during a Vertical jump. Gender influence was also investigated. Our findings support the hypothesis that a power exercise is more effective than a strength exercise in eliciting a Post activation potentiation. The 4-minute rest interval improved performance significantly for group mean data, whereas the 5-minute rest interval did not. However, when we looked at each subject individually, we discovered that some had a higher potentiation with the Others had a higher potentiation with the clean, whereas others had a lower potentiation with the squat. Similarly, for some subjects, the 5-minute rest interval outperformed the 4-minute rest interval in terms of improving Vertical jump height. Taken together, our findings suggest that Post activation potentiation is a highly individualized phenomenon that is not influenced by gender. Finally, the improved performance due to Post activation potentiation was due to an increase in the Ground reaction force impulse rather than an increase in the peak Ground reaction force. finally, he was saying that if the appropriate exercise and rest intervals are chosen for each individual, complex training can produce significant, acute increases in Vertical jump height. Currently, trial and error must be used to determine which athletes will respond better to a specific exercise or rest interval. Future research should concentrate on the individual effects of determining intra complex rest intervals and the heavy loaded resistance exercise performed prior to the plyometric exercise, as well as the long-term effects of complex training on jump performance. The results also showed that there is a statistically improvement in the group A and group B than other groups[26.]

Furthermore, the improvement in results of Group A is supported by the study done by Michal Lehnert, Ivona Lamrova et al who explained the mechanism behind the improvement of the vertical jump performance via plyometric exercises. They stated that plyometric exercises and weight training can be highly beneficial for vertical jump performance and the leg power which improves the vertical jump performance in volleyball players. A player jump performance can be improved with strength training of the lower limb muscles that enhances the ability of the jumping performance during the game play. plyometric increased flight time and decreased ground time significantly,it is their combination that caused the greatest gains in testing parameters. It has been suggested that the increased efficiency of plyometric movements and generally in stretch-shortening cycle exercises is due to the fact that previous stretching decreases the time inwhich positive work is done during the subsequent shortening. Training programs focused on developing basic strength and exercise technique initially, maximal strength later, and finally transition of maximal strength to power to improve the vertical jump height of players[27].

Deficiency in controlling the strength and the muscle power and coordination of the player performance can lead to drastically decrease the performance of the game play in volleyball game. It is well known about the muscle strength and power should plays an important role in the volleyball game. Here the results of the Orkhan Cdmenld, Hurmuz koc et al who worked on plyometric training for improving the vertical jump performance. The training program included

20 different plyometric exercise drills, which were performed over an 8-week period. Training surfaces play a crucial role in physical therapy. The training often takes place on tartan or wooden parquet surfaces, so it's important to investigate the impact of different training surfaces. We investigated how physical training on wooden parquet and sand surfaces affected agility, sprinting, and jumping performance in young basketball players. The goal of plyometric training is more elastic strength related. After concentric contractions, eccentric contractions could be used to apply a large amount of strength in a short period of time. Resistance can be overcome by high-speed neuromuscular system contractions, resulting in elastic force. This is a positive and negative type of strength training that aims to use kinetic energy and strength quickly while also improving explosive jump strength. Plyometric workouts make use of the elasticity found in connective tissues and muscle fibers. Muscle tension and slowing down are phases in which energy is stored, and contraction and acceleration are phases in which energy is released. During high jumping, the antagonist muscles extend, causing the muscle fibers to undergo a stretch reflex. The stretch reflex increases the stimulation of dormant muscles, causing them to contract more forcefully and quickly. finally, he concluded that in this study, anaerobic power and explosive strength capacity were improved with plyometric training; consequently, the experimental group's jumping height parameters showed notable increases[28].

Adams, Kent; O'Shea, John p et al had done a study on effects of plyometric training on vertical jump performance. This study clearly demonstrates the close relationship between neuromuscular efficiency (for example, multiple fiber recruitment and facilitation of the stretching reflex) and dynamic strength performance. Parallel squats are beneficial to the development of hip and thigh strength, and the simultaneous application of plyometrics allows for the effective use of this strength to produce explosiveness in sports or events that require speed and quickness. In other words, the role of plyometrics is to facilitate the neuromuscular system in making a more rapid transition from eccentric to concentric contraction, which generates maximum ballistic force. The contractile component of actin and myosin cross bridges with the sarcomere plays an important role in motor control and force development during plyometric exercises. The plyometric movement pre-stretches the muscle-tendon unit's physiological length-tension curve, increasing muscle fiber tension and force production. The author's work supports the biomechanical "priming" of the muscle. According to the Elftman proposal, muscle force production follows a predictable hierarchy. Eccentric muscle contractions generate the most force, followed by isometric contractions, and finally concentric contractions. Concentric muscle contractions are modes of muscle action. However, plyometrics generate the greatest forces[29].

Chaitanya D Sahasrabudhe et al had done a study on plyometric training he had explained the effects of plyometric training on volley ball players. High-speed contractions of the neuromuscular system can overcome resistance and produce elastic force. This hybrid positive-negative strength training approach seeks to increase explosive jump strength while utilizing kinetic energy and strength rapidly Selective motor unit recruitment enables the skeletal muscles to contract rapidly and voluntarily. It is widely acknowledged that the size principle—a systematic pattern or sequence—is followed in the recruitment of muscle fibers. At sub-maximal intensity efforts, slow twitch (ST) fibers are usually recruited, and as the intensity increases, fast twitch (FT) IIa fibers are recruited at roughly 30 percent up to about 80 percent of maximal intensity[30].

Furthermore, the improvement in results of Group A is supported by the study done by Ayu Novita Sari et al had done work on plyometric jump training. The proprioceptors found in the body, such as the muscle spindle, the Golgi tendon organ (GTO), and the mechanoreceptors found in the capsules surrounding the joints and ligaments, are the basis for the neurophysiology of plyometric exercises. This stimulation of the receptors facilitates inhabitation and modifies the muscles that are agonists and antagonists. The afferent nerve stimulation increased as the muscle spindle was stretched. The strain rate applied determined the strength of the signal transmitted to the spindle muscle's spinal cord. Stronger neurologic signals are sent from the muscle spindle and more muscle contraction results from faster stretching Golgi tendon organ is another mechanism that contributes significantly to the plyometric-shorten stretch. The Golgi tendon organ functions as a protective reflex to keep the muscles from tensing up or contracting too much. Golgi tendon organ therefore aids in power modulation during plyometric workouts. Plyometric exercise's objective is to enhance neural receptor stimulation to boost the neuromuscular system's reactivity while lowering Golgi tendon organ. Plyometric explosive exercise increased neuromuscular coordination, which in turn improved neural efficiency. Plyometric exercises therefore enhanced neuromuscular performance by raising the speed set in response to the muscle contraction. As a result, this mechanism led to an increase in neurological systems that facilitate the automation of neuromuscular coordination[31].

Some other supporting articles for group A are done by William R et al the aim was the study was to find out the effects of plyometric training on men's who are college going volley ball players. The modified plyometric jumps were not as similar to the Counter movement jump used in testing as the conventional depth jump training was. It's interesting to note that this explanation is corroborated by contrasting the test results for the Counter movement jump and spike jump. While the weight training and modified plyometric groups showed higher improvements in Squat Jump than in Counter Movement Jump, the Counter Movement Jump and conventional plyometric groups showed greater improvements in Counter Movement Jump. Eccentric muscle contractions produce the most force, followed by isometric contractions and then concentric contractions. Plyometric exercises therefore enhanced neuromuscular performance by raising the

speed set in response to the muscle contraction. Where plyometrics generate the highest forces[32].
The mean scores of pre-tests and post-tests are showed that both plyometric jump training and post activation potentiation exercises program were beneficial in improving vertical jump performance in players
From the finding of this study, it can be recommended that the plyometric jump training may be obtained by the strength and conditioning trainers and volleyball coaches in colleges as an adjuvant program for college going volleyball players to add in their regular training sessions.

LIMITATIONS

- The findings of this study are only applicable for college going volleyball players
- Less sample size
- No blinding

RECOMMENDATION FOR FURTHER RESEARCH

- Follow- up after 6 weeks could be useful to determine the improvement of performance in the college going players.
- Training Sessions per week can be increased to get better results

CONCLUSION

The present study concluded that six weeks program of plyometric jump training and post activation potentiation training were shown to be statistically significant in improving vertical jump performance in college going volleyball players. However superior significant improvement in outcomes were seen in group-A which received plyometric jump training.

REFERENCES:

1. kilic O, Maas M, Verhagen E, Zwerver J, Gouttebarge V. Incidence, aetiology and prevention of musculoskeletal injuries in volleyball: A systematic review of the literature.EurJSportSci.2017Jul;17(6):765-793. Epub 2017 Apr 9.
2. Bere T, Kruczynski J, Veintimilla N, Hamu Y, Bahr R. Injury risk is low among world-class volleyball players: 4-year data from the FIVB Injury Surveillance System. Br J Sports Med. 2015 Sep;49(17):1132-7. Epub 2015 Jul 20.
3. Polglaze T., Dawson B. (1992) The physiological requirements of the positions in state league volleyball. *Sports Coach* 15, 32-37.
4. Sheppard JM, Gabbett T, Taylor KL, Dorman J, Lebedew AJ, Borgeaud R. Development of a repeated-effort test for elite men's volleyball. Int J Sports Physiol Perform. 2007 Sep;2(3):292-304.
5. Soundararajan, R. and A. Pushparajan. "EFFECTS OF PLYOMETRIC TRAINING ON THE DEVELOPMENT THE VERTICAL JUMP IN VOLLEYBALL PLAYERS." *Citius Altius Fortius* 28 (2010): 65-69.
6. Augustsson SR, Augustsson J, Thomeé R, Svantesson U. Injuries and preventive actions in elite Swedish volleyball. Scand J Med Sci Sports. 2006;16:433–40
7. Takahashi S, Nagano Y, Ito W, et al. A retrospective study of mechanisms of anterior cruciate ligament injuries in high school basketball, handball, judo, soccer, and volleyball. Medicine .2019;98:e16030.
8. Sattler, Tine1; Hadžić, Vedran2; Dervišević, Edvin2; Markovic, Goran3. Vertical Jump Performance of Professional Male and Female Volleyball Players: Effects of Playing Position and Competition Level. Journal of Strength and Conditioning Research: June 2015 - Volume 29 - Issue 6 - p 1486-1493
9. Fatouros IG, Jamurtas AZ, Leontsini D, Taxildaris K, Aggelousis N, Kostopoulos N, Buckenmeyer P. Evaluation of plyometric exercise training, weight training, and their combination on vertical jumping performance and leg strength. The Journal of Strength & Conditioning Research. 2000 Nov 1;14(4):470-6.
10. Anitha J, Kumaravelu P, Lakshmanan C, Govindasamy K. Effect of plyometric training and circuit training on selected physical and physiological variables among male Volleyball players. International Journal of Yoga, Physiotherapy and Physical Education. 2018;3(4):26-32.
11. Bobbert MF. Drop jumping as a training method for jumping ability. Sports Med. 1990 Jan;9(1):7-22.
12. Bobbert, MJ, Mackay, M, Schinkelshoek, D, Huijing, P, and Van Ingen Schenau, GJ. Biomechanical analysis of drop and countermovement jumps. Eur J Appl Physiol 54: 566–573, 1986
13. Bosco, C, Vitasolo, JT, Komi, PV, and Luhtanen, P. Combined effect of elastic energy and myoelectrical potentiation during stretch shortening cycle exercise. Acta Physiol Scand 114: 557–565, 1982
14. Cavagna GA, Dusman B, Margaria R. Positive work done by a previously stretched muscle. J Appl Physiol. 1968 Jan;24(1):21-32.

15. de Villarreal ES, Kellis E, Kraemer WJ, Izquierdo M. Determining variables of plyometric training for improving vertical jump height performance: a meta-analysis. The Journal of Strength & Conditioning Research. 2009 Mar 1;23(2):495-506
16. Sale DG. Postactivation potentiation: role in human performance. Exerc Sport Sci Rev. 2002 Jul;30(3):138-43.
17. Robbins DW. Postactivation potentiation and its practical applicability: a brief review. J Strength Cond Res. 2005 May;19(2):453-8.
18. Chen ZR, Lo SL, Wang MH, Yu CF, Peng HT. Can Different Complex Training Improve the Individual Phenomenon of Post-Activation Potentiation? J Hum Kinet. 2017 Mar 12;56:167-175.
19. P. Berriel, Guilherme, S. Cardoso, Ananda, R. Costa, Rochelle, G. Rosa, Rodrigo, B. Oliveira, Henrique, Fernando M. Kruel, Luiz and A. Peyré-Tartaruga, Leonardo. "Effects of Postactivation Performance Enhancement on the Vertical Jump in High-Level Volleyball Athletes" Journal of Human Kinetics, vol.82, no.1, 2022, pp.145-153.
20. de Salles PG, Vasconc ellos FV, de Salles GF, Fonseca RT, Dantas EH. Validity and reproducibility of the sargent jump test in the assessment of explosive strength in soccer players. J Hum Kinet. 2012 Jun;33:115-21. Epub 2012 Jul 4.
21. Shaji, John T. and Saluja Isha. “Comparative analysis of plyometric training program and dynamic stretching on vertical jump and agility in male collegiate basketball player.” Journal of the Medical Sciences *2* (2009): 36-46
22. Kurathi Ruth Vatsalya, Pilladi Chaturvedi, Patchava Apparao&Ch. Ganapathi Swamy.Effectiveness of Contrast Training Versus Core Strengthening Training in Improvement of Dynamic Balance and Agility in Collegiate Badminton Players.International Journal of Current Medical and Applied sciences; 2023, 38(1), 06-12
23. Sarika S, Kaur MB, Shenoy S. Analyzing the effect of post activation potentiation on vertical jump height in volleyball players. European Journal of Physical Education and Sport Science. 2019 Jun 19.
24. Gahreman D, Moghadam MA, Hoseininejad E, Dehnou VV, Connor JD, Doma K, Stone M. Postactivation potentiation effect of two lower body resistance exercises on repeated jump performance measures. Biol Sport. 2020 Jun;37(2):105-112. Epub 2020 Feb 11.
25. Jastrzebski Z, Wnorowski K, Mikolajewski R et al. The effect of a 6-week plyometric training on explosive power in volleyball players. Balt J Health Phys Act. 2014; 6(2):
79-89
26. McCann, Matthew R; Flanagan, Sean P. The Effects of Exercise Selection and Rest Interval on Postactivation Potentiation of Vertical Jump Performance. Journal of Strength and Conditioning Research 24(5):p 1285-1291, May 2010.
27. Lehnert M, Lamrová I, Elfmark M. Changes in speed and strength in female volleyball players during and after a plyometric training program. Acta Gymnica. 2009 Oct 22;39(1):59-66.
28. Çimenli O, KOC H, CDMENLI F, KACOGLU C. Effect of an eight-week plyometric training on different surfaces on the jumping performance of male volleyball players. Journal of Physical Education & Sport. 2016 Mar 1;16(1).
29. Adams, Kent; O'Shea, John P.; O'Shea, Katie L.; Climstein, Mike. The Effect of Six Weeks of Squat, Plyometric and Squat-Plyometric Training on Power Production. Journal of Strength and Conditioning Research 6(1):p 36-41, February 1992.
30. Sahasrabudhe CD, Tendulkar S, Golhar S. Effectiveness of 6 Weeks Plyometric Training Protocol on Vertical Jump Ability among High School Amateur Male Volleyball Players-A Randomized Control Trial. Acta Scientific Orthopaedics (ISSN: 2581-8635). 2020 May;3(5).
31. Sari AN, Maulang I, Darwis A. Effect of plyometric depth jump exercise toward vertical jump changes of volleyball players UKM, Hasanuddin University. In Journal of Physics: Conference Series 2020 Apr 1 (Vol. 1529, No. 3, p. 032028). IOP Publishing.
32. Holcomb, William R.1; Lander, Jeffrey E.2; Rutland, Rodney M.3; Wilson, G. Dennis3. The Effectiveness of a Modified Plyometric Program on Power and the Vertical Jump. Journal of Strength and Conditioning Research 10(2):p 89-92, May 1996.

. **ANNEXURE - I**

CHAIRMAN
Mr. Naveen
Social Activist

INSTITUTIONAL ETHICS COMMITTEE
GSL MEDICAL COLLEGE & GENERAL HOSPITAL,
NH-16, RAJAHMUNDRY [ANDHRAPRADESH] – 533296

GSLMC/ RC:940-EC/940-09/2022 *Date: 19.09.2022*

Communication of Decision of the Institutional Ethics Committee [IEC] - Institutional Review Board [IRB]

To: Mr. DUVVURU GOWTHAM KUMAR, 1st year MPT (Sports), GSL COLLEGE OF PHYSIOTHERAPY & REHABILITATION, Rajahmundry

IEC/IRB Ref No: 940-EC/940-09/22

Protocol Title: "COMPARISON OF PLYOMETRIC JUMP TRAINING VERSUS POST ACTIVATION POTENTIATION FOR IMPROVING VERTICAL JUMP PERFORMANCE IN COLLEGE GOING VOLLEY BALL PLAYERS"								
Principal Investigator: : Mr. DUVVURU GOWTHAM KUMAR								
Name & Address of Institution: GSL COLLEGE OF PHYSIOTHERAPY & REHABILITATION, Rajahmundry								
New review	√	**Revised Review**		**Expedited review**				
Date of review [D/M/Y]	1	9	0	9	2	0	2	2
Date of previous review (if revised application)								
Documents reviewed:								
Current CV of the investigator	√	Trial protocol	√	Investigator's Brochure	√			
Proposed methods	√	Informed consent form	√	Agreement with the Sponsor				
Compensation protocol	√	Investigators undertaking	√	Case Report Form	√			
Any other/ additional documents (Specify)								
Decision of the IEC / IRB:								
Recommended √	Recommended with suggestions		Revision		Deferred		Rejected	
Suggestion/Reasons/Remarks: APPROVED √								
Recommended for a period of :								
One Year		Three Years √		Five Years				

Please note:

- Inform IEC/ IRB immediately in case of any Advance events and Serious adverse events
- Inform IEC/IRB in case of any change of study procedure, site and investigator.
- This permission is only for period mentioned above. Annual report to be submitted to IEC/IRB.
- Members of IEC/IRB have right to monitor the trial with prior intimation.

Signature of **MEMBER SECRETARY**
IEC/IRB

MEMBER SECRETARY
INSTITUTIONAL ETHICAL COMMITTEE
GSL Medical College & General Hospital
NH-5, Rajahmundry 533 296
GSL Medical College
NH-5, Lakshmipuram,
Rajahmundry - 533 296