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Combined Effect of Proprioceptive Training and Strength Training on Vertical Jump in Amateur Basketball Players: An Experimental Study

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ABSTRACT

Aim- To study the combined effect of proprioceptive training and strength training on vertical jump in amateur basketball players.

Relevance of study: The study reflects that athletes can maximize their potential for achieving greater jump height and overall performance while minimizing the risk of injury.

Methodology: In this experimental study, 36 subjects were recruited according to inclusion and exclusion criteria and were divided into two groups Group A (Experimental group) and Group B (Control group) by using Simple Lottery method. Pre and post analysis was done using vertical jump test. Combined proprioceptive and strength training was given to subjects for 3 weeks, 5 days per week.

Result: A p value of 0.0105 obtained on intergroup comparison between experimental and control group using unpaired t test which is <0.05 indicates that there is a statistically significant difference between the experimental and control groups. Thus, it implies that there was a significant increase in vertical jump height due to combined effects of strength training and proprioceptive training in amateur basketball players.

Conclusion: Combined proprioceptive training and strength training is effective in improving vertical jump height in amateur basketball players.

KEYWORDS: Basketball players, Proprioceptive Training, Strength training, Vertical jump.

INTRODUCTION

Basketball is an indoor game of five players played between two teams of each on a rectangular court. Each team tries to score by tossing the ball through the opponent's goal, an elevated horizontal hoop and a net called a basket [1]. 11% of the world plays basketball and the Fédération International de Basketball (FIBA), the International governing body of basketball, now represents 212 member nations and 450 million registered participants. Thus Basketball is one of the most popular physical activities in the world [2]. The basketball jump shot (JS) involves complex tutoring and learning processes and is considered a high-complexity-specific motor skill [3].

Michaud et al. reported an increased risk of injury occurrence with pubertal development (Tanner stage 4 or 5) rather than chronological age [4].

Explosive force is the capability of a muscle to perform a specific muscular effort in a minimal time; it is a combination of motor qualities such as strength and speed and is specific to basketball where rapid, powerful movements are crucial for performance. International scientific research underlines the importance of jumping ability in basketball as it is used in many moves in basketball from rebounding, defending, dynamic jumps to recover the ball, sudden jumps to throw the ball, dynamic actions to score baskets, and, in general, the entire dynamic action involved in the game requires the jumping motion ability, which is closely related to the nature of the explosive force and speed of the game [5].

Proprioceptive or balance training, also called sensorimotor training was originally proposed by clinicians as one of the rehabilitative exercise concepts [6, 7]. Proprioception is the sense or ability to perceive the position sense of the body and the velocity of body movements, resistance, and weight [4]. It is the reception of stimuli produced within an organism and refers to the conscious and unconscious perception of postural balance, muscle sense, and joint stability. As proprioception plays a major role in joint stability and injury prevention, is important in sports. Proprioception represents activities that help individuals gain a better conscious awareness of their body and limbs in space called as Joint Position sense [9, 10]. It combines static and dynamic aspects [8, 11] to include passive motion sense, active motion sense, limb position sense, and sense of heaviness, which provide feedback to the neuromuscular system.

This feedback is performed by stimulating muscle spindles, Golgi tendon organs, and various joint afferents (Pacinian corpuscles, Meissner's corpuscles, Merkel's Discs, Ruffini endings, and free nerve endings) [12, 13] which arises from our peripheral nervous system (PNS), and feed information to our central nervous system (CNS), both at the level of the spinal cord (reflexive) and sent to the cerebral cortex for higher processing [14]. It advances the complex activity of the neuromuscular system [15].

Strength training refers to a specialized method of conditioning, which involves the progressive use of a wide range of resistive loads such as free weight, resistance bands, bodyweight exercises, and other equipment and a variety of training modalities designed to enhance health, fitness, and sports performance. Although the terms resistance training, strength training, and weight training are sometimes used synonymously, the term strength training encompasses a broader range of training modalities and a wider variety of training goals [16]. This form of training involves lifting heavy weights while completing a small number of repetitions [17]. It is a crucial methodology when the aim is to develop higher levels of muscular strength and power implied in basketball jumping [18].

A properly designed and supervised resistance training program has an effect on intrinsic muscular adaptations, motor coordination, and neuromuscular activation improves motor skill performance, and may contribute to enhanced sports performance of youth and increase a young athlete's resistance to sports-related injuries [16].

Central effects include greater body awareness due to the improved sense of the position and movement of joints [15]. Peripheral impacts of training are seen in a better reflex intermuscular coordination of agonists and antagonists, i.e. in an optimal regulation of the joint fixation using dynamic stabilizers [15]. Besides, there is an increase in the rate of force development during voluntary muscular contraction suggesting the possibility of proprioceptive training influence on the neuromuscular system due to the initiation of the generated force, i.e. an improvement of explosive strength and neuromuscular activation at the start of a voluntary muscular activity [15]. The explosive force generation in vertical jumping performance is influenced by the rapid transfer from eccentric to concentric muscle work (stretch-

shortening cycle), leading to an effect on the quick generation of strength as well as on the higher rate and early inclusion of motor units, thus leading to the increase in the vertical jump height [19].

MATERIALS

1. Pen
2. Paper
3. BOSU ball
4. Chalk
5. Measuring tape or stick
6. A smooth wall with relatively high ceiling
7. Step stool or small ladder

METHODOLOGY

Study Design - Experimental Study
Method of Sampling- Simple Random Sampling by using Lottery method
Sample Size-36
Study Setting - Pioneer Sports Association, Jalgaon
Study Duration- 6 months
Study Population- Amateur basketball players of age group between 10-18yrs
Selection Criteria- 36 participants were included in the study according to inclusion and exclusion criteria.

Inclusion criteria-

- 10-18 yr old male and female playing basketball having training experience >3months.
- Subjects capable of bending knees and jumping, and fit enough to engage in balance training.
- Male and females who are willing to participate.

Exclusion criteria-

- Subjects having specific previous injury to knee or ankle.
- Subjects with knee pain.
- Muscular dystrophy.
- Balance-related pathologic conditions.
- Joint-related pathologic conditions (Ankylosing spondylitis).
- Using an assistive device (cane, walker).
- Lower limb surgeries (ACL reconstruction surgeries, ankle repair).
- Body mass index >30 kg/m^2.

OUTCOME MEASURES

Vertical jump test
Objective: To evaluate standing vertical jump height. Measure lower limb explosive power by measuring the height a client is able to jump.

Equipment:

- A smooth wall with relatively high ceiling.
- A flat, stable floor that provides good traction,

- Chalk (different color than the wall).
- Measuring tape or stick.
- Stepstool or small ladder.

Assessment protocol and administration:

- After explaining the purpose of the vertical jump assessment, describe and demonstrate the procedure. Allow the client to perform a few practice trials before administering the assessment.
- Instruct the client to stand adjacent to a wall, with the inside shoulder of the dominant arm approximately 6 inches (15 cm) from the wall. Measure the client's standing height by marking the fingers with chalk, extending the inside arm overhead, and marking the wall. This mark will then be compared to the maximal height achieved on a vertical jump.
- The client then lowers the arms and, without any pause or step, drops into a squat movement before exploding upward into a vertical jump.
- The goal of this assessment is to jump as high as possible from a standing position.
- Since proper technique plays a role in achieving maximal jump height, encourage the client to use the arms and legs for propulsion.
- At the highest point, the athlete touches the wall, marking it with chalk.
- The vertical jump measurement is determined by the vertical distance between the new chalk mark and the starting height
- Allow three repetitions and record the maximal height achieved on the assessment form.
- Use the table below to categorize the client's performance :

Norms for the Vertical Jump Assessment (cm)

Men						
Age (years)	15–19	20–29	30–39	40–49	50–59	60–69
Excellent	≥56	≥58	≥52	≥43	≥41	≥33
Very good	51–55	54–57	46–51	36–42	34–40	29–32
Good	46–50	48–53	40–45	32–35	28–33	25–28
Fair	42–45	42–47	31–39	26–31	18–27	18–24
Needs Improvement	≤41	≤41	≤30	≤25	≤17	≤17
Women						
Age (years)	15–19	20–29	30–39	40–49	50–59	60–69
Excellent	≥40	≥38	≥36	≥31	≥25	≥19
Very good	36–39	34–37	32–35	27–30	21–24	15–18
Good	32–35	29–33	28–31	23–26	16–20	11–14
Fair	28–31	25–28	24–27	18–22	10–15	7–10
Needs improvement	≤27	≤24	≤23	≤17	≤9	≤6

PROCEDURE

Ethical clearance was obtained from Institutional ethical committee.

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Subjects were selected according to the selection criteria and those willing to participate

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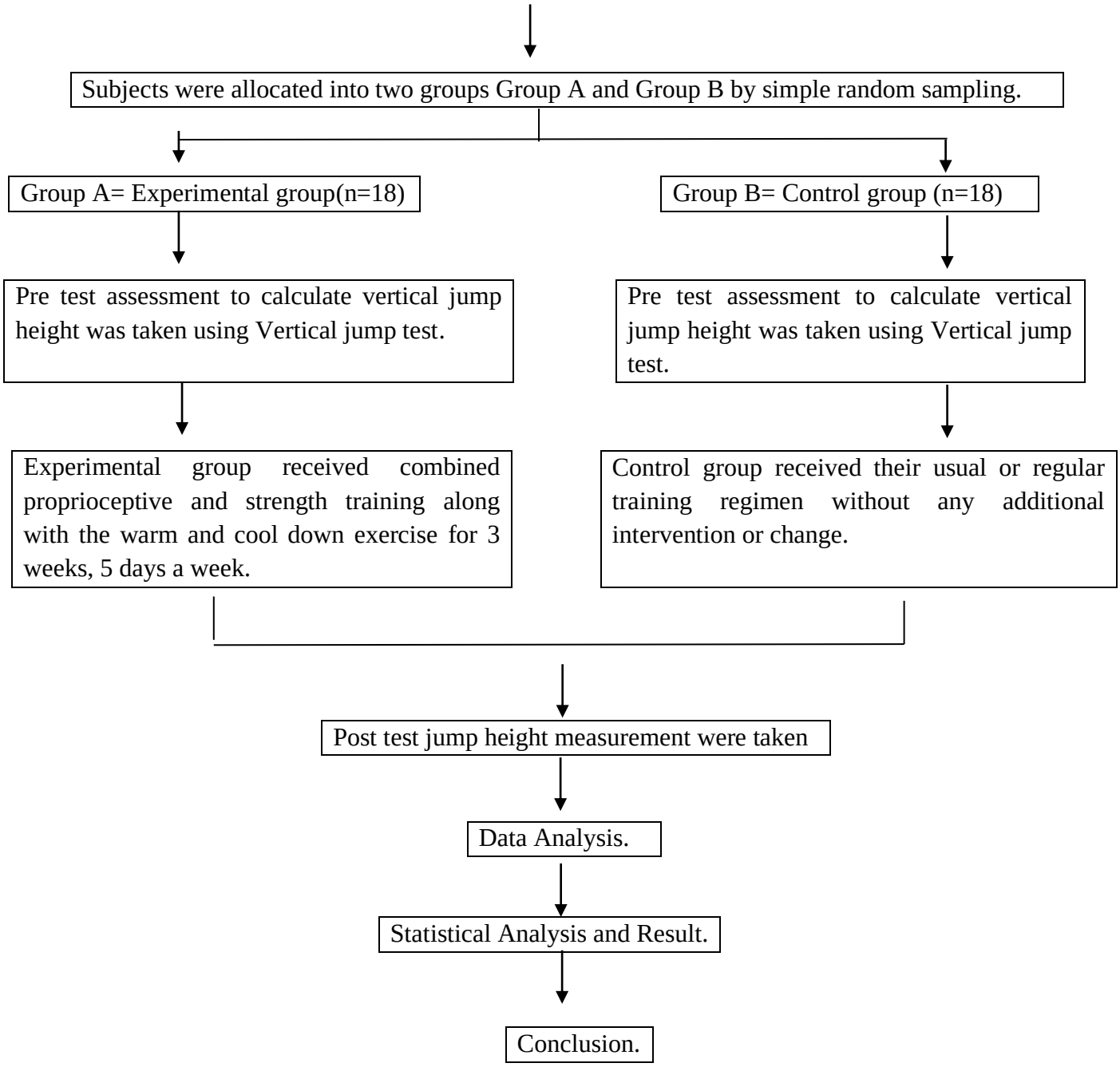
Informed consent was taken from the individuals and the study was explained to them.



INTERVENTION:

- In this experimental study, 36 participants were recruited. They were divided into 2 groups, Experimental group (n=18) and Control group (n=18).
- Experimental group received combined strength and proprioceptive training and the Control group received their usual or regular training regimen without any additional intervention or change.

FOR PROPRIOCEPTIVE TRAINING:

1. BOSU Ball Exercises:-

- moving forward, backward, left, right
- Standing on 1 leg with eyes open and closed for 30 sec
- Swinging leg forward, backward, and lateral while standing on one leg on the BOSU Ball (8 x2)

- Squats on both the legs standing on BOSU Ball 3x 10 (recovery time 30 s)

2. Tandem walking exclusively forward for 1min
3. Calf Raise gait or toe walking only forward for 2 min

Figure 1: Moving forward, backward, left, right standing on the BOSU ball

Figure 2:Swinging leg forward, backward, and lateral standing on the BOSU ball

Figure 3: Swinging leg forward, backward, and lateral while standing on one leg on the BOSU Ball

Figure 4: Squats on both the legs standing on BOSU Ball

FOR STRENGTH TRAINING:

Excercises	Frequency	Rest Interval	Duration	Type	Repetitions
1)Standing Squats 2)Walking lunges 3)Step up and step down	5 days a week for 3 weeks (15 sessions in total)	1-2 min rest interval	40 min-Subjects received warm up session for 5 mins, proprioceptive training for 15 min and strength training for 15 min and 5mins of cool down period.	Functional Body weight (use of own body mass	10-12 reps x 3 sets

4)Standing calf raises					

Figure 5: Standing Squats

Figure 6: Walking lunges

Figure 7: Standing calf raises

Figure 8: Step up and step down

STATISTICAL ANALYSIS

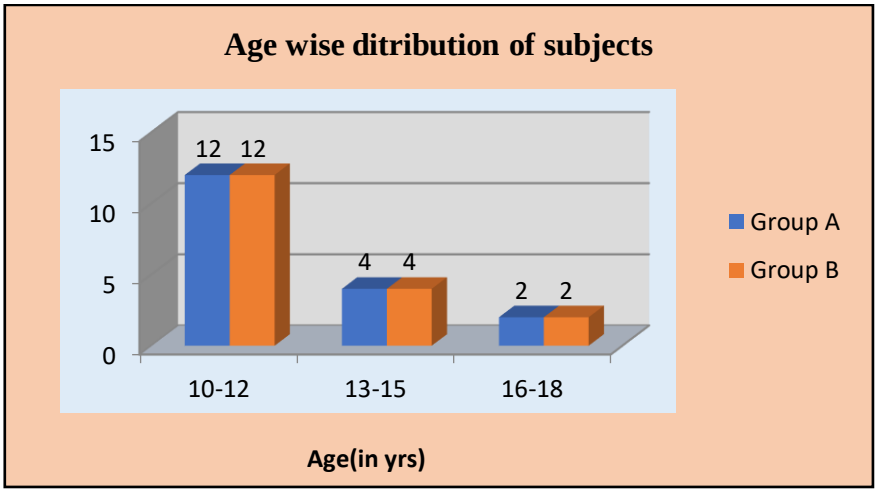
- The data was entered in MS Excel before it was statistically analysed using "Graphpad Instat Version 3.05".
- All the results are shown in tabular as well as graphical format to visualize the statistically significant difference more clearly.
- The data on the quantitative characteristics was presented as Mean ± SD across study group.
- The paired t test was used to compare between intragroups of both experimental and control group respectively and the unpaired t test was used for comparison of intergroup analysis between control and experimental group.

OBSERVATION AND TABLES

Table 1:- The Age wise distribution of the subjects.

Age (in yrs)	Group A	Group B	Total no. of participants	Percentage
10-12	13	11	24	67%
13-15	4	3	7	19%
16-18	1	3	4	11%

Graph 1:- The Age wise distribution of the study subjects.



In the study, 24 participants were between 10-12yrs of age 7 were between 13-15 yrs of age and 4 were between 16-18yrs of age.

Table 2:- The Gender Wise Distribution of study subjects.

Gender	Experimental Group	Control Group	Total
Male	12	9	21
Female	6	9	15

- In Experimental group, 12 were males and 6 were females.
- In Control group, 9 were males and 9 were females.

Graph 2: The gender Distribution of study subjects:-

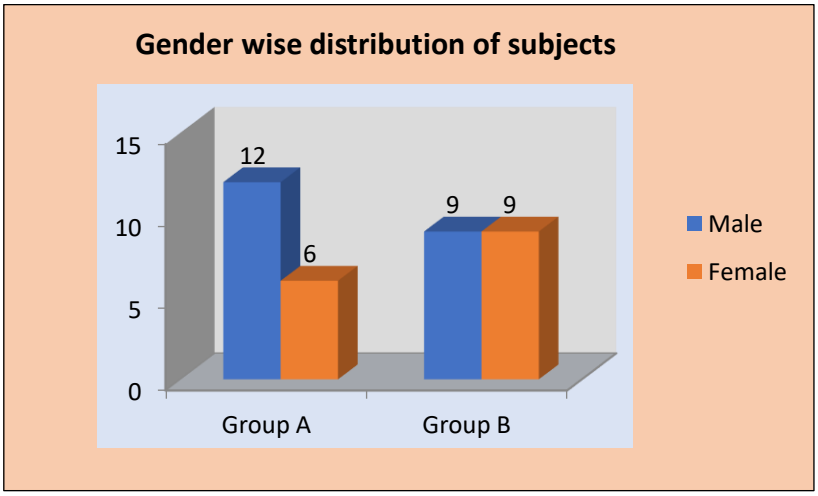


Table 3: Comparison of jump height between pre-test and post test in Experimental Group using Paired t test

Jump Height	Mean	± SD	T Value	P Value	Significance
Pre-test	22.950	5.467	30.611	<0.0001	Extremely Significant
Post-test	30.961	6.286			

A p-value of <0.0001 which is <0.05 found on Comparison of jump height between pre-test and post test in Experimental Group using Paired t test is considered extremely significant.

Graph 3: Intra group analysis of jump height in experimental group

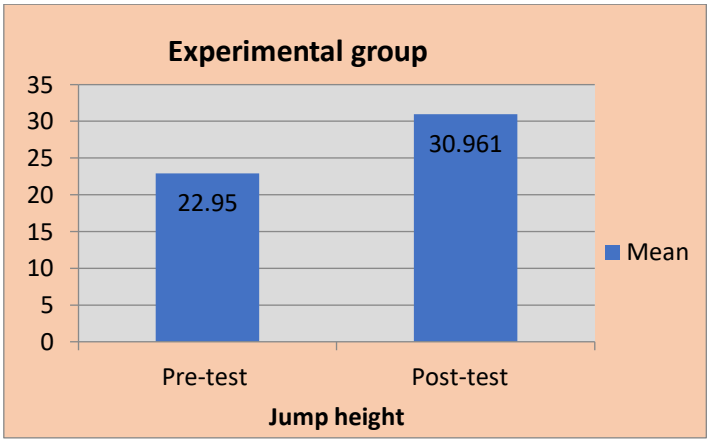


Table 4: Comparison of jump height between pre-test and post-test in Control Group using Paired t test.

Jump Height	Mean	± SD	T Value	P Value	Significance
Pre-test	25.344	4.569	2.544	0.0210	significant
Post-test	26.139	4.554			

On comparison between pre and post test in control group, p value was found to be 0.0210 which is <0.05 and is considered as significant.

Graph 4: Comparison of jump height between pre-test and post-test in Control Group

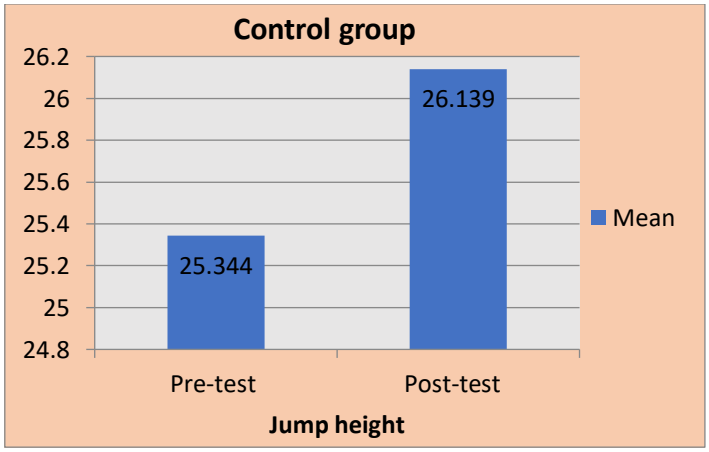
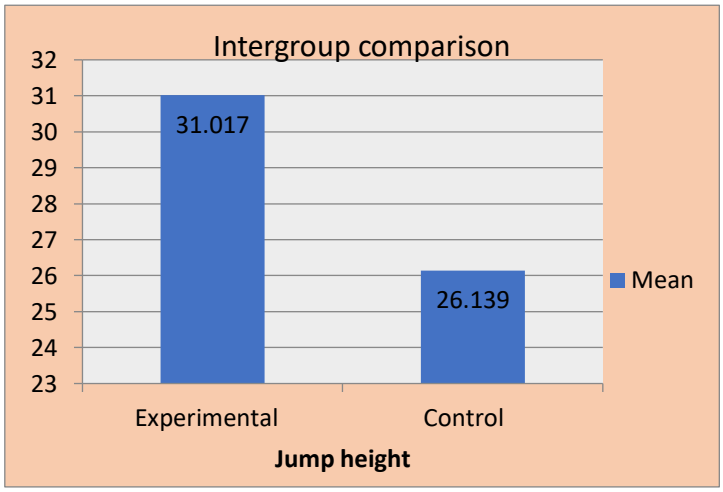


Table 5: Intergroup Comparison between experimental and control group using unpaired t-test.

Jump Height	Mean	± SD	T Value	P Value	Significance
Pre-test	31.017	6.131	2.710	0.0105	significant
Post-test	26.139	4.554			

Intergroup comparison between experimental and control group using unpaired t test, p-value was found 0.0105 which is <0.005. Hence, it implies that there is a significant increase in the vertical jump height in basketball players by combined effect of strength training and proprioceptive training.

Graph 5: Intergroup Comparison between experimental and control group



RESULTS

- A p value of 0.0105 obtained on intergroup comparison between experimental and control group using unpaired t test which is <0.05 indicates that there is a statistically significant difference between the experimental and control groups.
- Thus, it implies that there was a significant increase in vertical jump height due to combined effects of strength training and proprioceptive training in amateur basketball players.

DISCUSSION

- The jumping ability is used in many moves in basketball from rebounding, defending, dynamic jumps to recover the ball, sudden jumps to throw the ball, dynamic actions to score baskets, and, in general, the whole dynamic action involved in the game requires the jumping motion ability and are related to the nature of the explosive force and speed of the game.
- The Explosive force and speed required in basketball demand players to have strong and efficient jumping abilities to excel in various game situations. Therefore, enhancing jump height through strength and proprioceptive training can significantly impact a player's performance on the court.
- As vertical jump height is a key performance indicator in basketball, understanding how different training modalities can influence it can provide valuable insights for optimizing athletic performance and injury prevention strategies in this population.
- By combining proprioceptive training, which enhances balance and body awareness, with strength training improves muscle strength and power. The study aims to comprehensively assess the impact of vertical jump height, which is essential for various aspects of gameplay.

- The study contains 36 participants, out of which there are 58% of male subjects and 42% of female subjects. In this study, the participants are between the age group of 10-18 years which are subdivided into 3 groups i.e. 10-12, 13-15, and 16-18.
- Vertical jump height was measured using vertical jump assessment/ Sargent jump test pre-intervention and 3 weeks of proprioceptive training along with strength training was given to the subjects and the jump height was reassessed post-intervention.
- On statistical analysis, a p-value of 0.0105 obtained on intergroup comparison between the experimental and control group using unpaired t-test is <0.05 which is statistically significant. Thus, it implies a substantial increase in vertical jump height due to the combined effects of strength and proprioceptive training.
- Proprioceptive training improves joint stability and alignment by enhancing proprioception, which is the body's ability to sense its position in space. This improved stability ensures that the force generated during the jump is effectively transmitted through the kinetic chain, leading to a more efficient and powerful jump. It focuses on enhancing neuromuscular coordination and body awareness. Improved coordination allows players to efficiently recruit the appropriate muscles and generate maximal force during the take-off phase of the jump, allowing for higher vertical propulsion.
- Strength training can lead to hypertrophy and changes in muscle fiber composition, particularly an increase in fast-twitch muscle fibers, which are important for explosive movements like jumping because they generate high force outputs over short durations and thus enhance explosive power.
- The cumulative effect of the repetitive exposure to traction forces applied to passive structures such as ligaments and capsules would increase their resilience to impulsive stress.
- The plasticity of tendons and ligaments refers to their ability to adapt to variations in mechanical loading by adjusting their size and material properties. This adaptation process known as mechanotransduction, involves the conversion of mechanical signals into biochemical responses within the cells of these connective tissues. Through mechanisms such as remodeling, changes in cross-sectional area, and alterations in the composition of extracellular matrix components, tendons, and ligaments can strengthen and become more resilient in response to increased mechanical loading, such as that experienced during strength training and dynamic movements in sports like basketball.
- This increased resilience helps in providing additional support and stability to the joints, particularly when the muscles are fatigued or unable to provide sufficient protection (enhancing their protective action when the muscle protection is overcome) and its adaptive capacity is crucial for optimizing tissue function and minimizing the risk of injury during athletic activities.
- In essence, the strengthening of passive structures complements the protective action of muscles, contributing to overall injury prevention and enhancing the athlete's ability to withstand impulsive stresses during intense gameplay consistently.
- Overall, the combination of proprioceptive and strength training optimizes neuromuscular coordination, muscle strength, joint stability, and injury prevention, all contributing to improved vertical jump height in basketball players.
- Riva et al. hypothesized that refined and enduring proprioceptive control in a single stance would minimize the injurious forces and improve the capability of absorbing them, allowing better interaction with the ground.

- A study conducted by Granacher et al. that in adolescents, lower extremity Ballistic strength training is a suitable training modality in a school setting (particularly during physical education lessons) that produced transient improvements in strength variables. These results in improving the performance level in various motor fitness skills and sports activities in physical education.
- Charles Son et al. concluded that 1 week of strength training or proprioceptive training had no statistically significant impact on vertical jump performance and proprioceptive training was effective in improving vertical jump performance after 1 week of training. A longer training study would be needed to elucidate differences between strength training and proprioceptive training for vertical jump.

CONCLUSION

The study has concluded that there is significant combined effect of proprioceptive training and strength training in improving vertical jump height in amateur basketball players.

LIMITATIONS

- The study does not specify which training (either proprioceptive or strength) was more effective in improving the vertical jump height.
- No long term follow up was maintained.

FUTURE SCOPE OF STUDY

- Jump velocity can also be measured.
- Core strengthening can also be included along with this study to see the effect on jump height.
- Only a specified gender can be selected or equal gender distribution for further studies.
- Further studies can include long period of duration.

CLINICAL IMPLICATIONS

Improving jump height through strength training and proprioceptive training can have significant benefits for basketball players. Not only does it enhance their athletic abilities by allowing them to jump higher, which is crucial for scoring, rebounding, and defending, but it can also help in preventing injuries. Strength training helps build muscle strength and power, while proprioceptive training improves balance, coordination, and body awareness, all of which are essential for agility and injury prevention on the basketball court. By incorporating these training methods, basketball players can enhance their performance and reduce the risk of injuries.

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