EFFECTIVENESS OF A NEUROMUSCULAR TRAINING IN IMPROVING THE AGILITY AND VERTICAL JUMP PERFORMANCE IN HURDLERS.

DISSERTATION

Submitted for the partial fulfillment of the requirement for the degree of

MASTER OF PHYSIOTHERAPY (MPT)

ELECTIVE: ADVANCED PHYSIOTHERAPY IN SPORTS

Done by

N.PONRAJ

Bearing Registration NO:271550225

Submitted to

THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

CHENNAI- 600 032

APRIL - 2017

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Prof. R. RADHAKRISHNAN, M.P.T, PGHDM.

SEAL & SIGNATURE OF PRINCIPAL

Place: Chennai

Date:

MOHAMED SATHAK A. J. COLLEGE OF PHYSIOTHERAPY

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SIGNATURE OF GUIDE

PROF.S.PARANTHAMAN MPT

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Place: Chennai

Date

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Nungambakkam, Chennai – 600 034.

CERTIFICATE

This is to certify that the dissertation entitled **"EFFECTIVENESS OF A NEUROMUSCULAR TRAINING IN IMPROVING THE AGILITY AND VERTICAL JUMP PERFORMANCE IN HURDLERS"** was done by N.PONRAJ bearing Registration No: 271550225The undersigned examiner has duly verified and examined the submitted dissertation done by the above candidate.

....

INTERNAL EXAMINER **EXTERNAL EXAMINER**

Place: Chennai

Date:

DECLARATION

I hereby present and declare my dissertation titled **"EFFECTIVENESS OF A NEUROMUSCULAR TRAINING IN IMPROVING THE AGILITY ANDVERTICAL JUMP PERFORMANCE IN HURDLERS"** the outcome of original research work undertaken and carried out by me, under the guidance of **PROF S.PARANTHAMAN MPT at Mohamed Sathak A. J. College of Physiotherapy,** Chennai.34. I also declare that the material of this dissertation has not formed in any way the basis for the award of any other degree previously from The Tamil Nadu Dr. M.G.R Medical University,Chennai-32.

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SIGNATURE OF CANDIDATE

Place: Chennai

Date:

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1.INTRODUCTION:-

Hurdlers is one of the most popular team sport exclusively played and viewed all over the world. (**Matavulgi, 2001).** It was created by JAMES NAISMITH in 1981 in SPRINGFIELD, and through time it has developed to involve common techniques of shooting, passing, dribbling including player's positioning as well as offensive and defensive structure. (**Gerard A Malanga, 2006**) [15].

Primarily competitive Hurdlers developed as an indoor sport and evolved into less regulated outdoor sport as a casual play in the ground It is an especially popular high school sport which is unfortunately, associated with twice as much of injuries as baseball and 40% more injuries than football in one series. (**Matavulgi, 2001**) Hurdlers injuries are most common among all sports injuries ranging between 3.8% and 23.1% of all sports injuries (**Meeuwisse etal 2003**) [56]. These include injuries to the ankle (15.8%–39.3%), knee (5%–20%), hand (8.8%–43%), head and neck (8%–36.4%), and lumbar spine (0%–11.7%)

Non-contact injuries account for the most injuries in non-elite players. Due to the greater biomechanical efficiency in elite players, they have a higher incidence of contact injuries, though Non-contact injuries are still common. The high level of cutting and jumping activities required for a Hurdlers player places him in risk of injuries due to poor cutting activities and faulty jumping and landing mechanics. (**Gerard A Malanga, 2006**)[15].

Landing accounts for 60% of ACL injuries in high school Hurdlers players, (**Piasecki etal)**. Improving the Dynamic stability, through training the Neuromuscular system facilitates prevention of sports injuries and enhances performance.

A possible strategy for minimizing the risk of ACL injuries is a prehabilitation program with a focus on optimizing hip biomechanics during squatting and plyometric activities

Finally, the athlete should progress to more functional sports-specific activities, such as jumping and agility drills,

Hurdlers is a sport of speed, quickness, strength & power. To play competitively a hurdlers player needs to be strong, powerful, agile & flexible with good stamina & muscular endurance **(John Shaji etal, 2009**) [30].

A hurdlers player needs the ability to rapidly switch between forward, backward, lateral & vertical movements. (**Cosser etal, 1999, Diallo etal, 2001)** to overcome the problem of injuries. For attaining proper speed, forward, lateral & vertical movements, a hurdlers player needs good balance, agility and vertical jumping ability to achieve sporting targets. (**Delextrat A etal, 2008) [9].**

Players and coaches work to attain a greater maximum vertical jump to enhance performance in sport. Not only does greater vertical jump allow the athlete to play" closer to the rim," reach be ball first, and so on, but it is an excellent and reproducible indicator of whole -body power **(Kevin Ford etal,2006) [17]**.

There are several different training methods used to increase the maximum vertical jump height. **Newton et al**. demonstrated that ballistic resistance training is effective in improving vertical jump performance in elite jumping athletes. Landing mechanics and lower-extremity strengthening have also been shown to affect vertical jump height (**Hewett etal, 1996**) **[19].** Following short-duration (6 weeks) plyometric training, **Hewett et al**. found an approximate 10% increase in mean vertical jump height in women athletes.

Jump training programs incorporating stretching, plyometric exercises, and weight lifting have been advocated to increase performance and decrease injury risk in competitive athletes in jumping sports. A number of high school, collegiate, and Olympic sports teams have developed such programs. (**Timothy E Hewett etal, 2005) [23]** It is not known whether these programs alter jumping and landing biomechanics; only performance changes have been reported

Flexibility is often overlooked as a factor in leaping ability of a player; jumping high is based on the elasticity of muscles and tendons. Without extreme flexibility, one can never jump as high as he can with proper training. Flexibility can be attained by proper stretching, it is a technique to elongate the muscle. Dynamic stretching as well as plyometric exercises is commonly used to enhance vertical jump and agility. Various studies have been done to see the effect of dynamic stretching and plyometrics on vertical jump and agility in different sports and age groups. Majority of research literature prove it to be effective and accepted globally. (**John shaji etal, 2009)** [30]

Poor balance is associated with increased injury risk among the hurdlers players. Neuromuscular training programs have been advocated in improving the static & dynamic balance, single limb stability & joint dynamics through improved neuromuscular control. (**Griffin** [13]**, 2003, Hewett** [23]**, 2005, Valovich** [52]**, 2009).**

Moreover, bones, ligaments and joint capsule provide passive restraints and the dynamic or active restraint is provided by the neuromuscular system. Hence, to improve the dynamic stability training should be directed towards strengthening the dynamic restraints which helps in decreasing the reaction time and increasing the magnitude of muscle contraction. This can be easily achieved through training the neuromuscular system (**Christena W. Linford, 2005**) [5].

Agility is a specific athletic attribute that is fundamentally important to sports performance for three reasons. First, developing agility will provide a strong foundation for neuromuscular control and motor skill function, thereby establishing overall athleticism. Second, changing directions is a common cause of injury, so by teaching individuals proper movement mechanics we may be able to reduce injury risk.

Finally, as an athlete matures, a heightened ability to quickly change directions will enhance overall performance in both proactive offensive and reactive defensive

circumstances (**Little, T. and A.G. Williams2005)**. In order to appropriately develop agility both general and specific drills are used within particular windows of time.

Balance, Flexibility, Agility, Strength Power, are all components of a proper neuromuscular element. A strong muscle can contract, efficiently if and only if the Gamma Moto neuron drive is increased. This Gamma Moto neuron drive influences both the muscle spindle sensitivity by lowering its threshold and the reaction time, thereby increases the speed of contraction and reduces the electromechanical delay. (**Christena W. Linford, 2005**) **[5].**

The two main components which directly influence the performance of a Hurdlers player are the speed and the magnitude of the muscle contraction. The speed of muscle contraction directly influences agility which is the ability to quickly change directions & react faster.

The main performance of a Hurdlers player is rated by his ability to jump higher and reach the ground. Hence, the performance depends upon the agility of a person to quickly change the directions and the vertical jump, the ability of a person to jump higher. **(Michael G Miller etal [17], 2006, Arabatzi[2], etal, 2010)**

For improving the agility and vertical jump training should be concentrated more on the neuromuscular system. Also, Neuromuscular control deficits place undue stress on the passive ligamentous structures that may exceed their strength limit and potentially lead to mechanical failure, causing injuries to ligaments which are more common in knee and Ankle. (**Christena W. Linford [5], 2005, Markovic G , [16] 2007).**

Many studies have focused on including a proper Neuromuscular training comprising of FUNCTIONAL STRENGTHENING, CORE STRENGTHENING, STRETCHING, PLYOMETRICS, BALANCE TRAINING and AGILITY TRAINING, 2 times a week for

6 weeks to gain neuromuscular control, used in the prevention of injuries (**Griffin et al, 2003)**[13].

Proven studies are there to explain the benefits of Neuromuscular training in reducing the risk of sports injuries, these studies aimed at prevention of injuries, few studies focused on improving the sport performance through either Balance or plyometric training, one component of the Neuromuscular training (**Michael G Miller, 2006)**[17]**.**

This study evolved as a means to find out whether an integrative Neuromuscular training program when included in the prehabilitation conditioning program proves beneficial in improving the Vertical jump performance & Agility in a Hurdlers player.

2. NEED FOR THE STUDY:-

Many high Quality studies have proven the benefits of an effective Neuromuscular training program in reducing the risk of injuries in competitive sports requiring pivoting and jumping activities like soccer, hurdlers, volley ball, hand ball, etc (**Hewett etal[20], 1999, Christine Bialkowski, etal[6],2006, Myer GD etal,2005 [38]).** Even, studies have been done for improved biomechanical efficiency and landing mechanics after Neuromuscular training in those Players (**Myer, etal, 2008**) [36].

Neuromuscular training has been proven to be effective in Rehabilitation of ACL injuries & in ACL reconstruction and also in reducing the risk of ACL injuries in female athletes. All these studies have focused on the injuries & its prevention. In addition if these neuromuscular training programs are able to improve athletic performance, it will be beneficial for the coaches & the players which also help to maintain the compliance of the player towards the training. Having programs to improve athletic performance such as balance, agility, vertical jump & strength may be an additional incentive for the players to comply & participate in the training. (**Holm, etal[28], 2007, Paterno, etal[45], 2004).**

Few studies have concentrated on the performance of the Hurdlers players in which improvements in balance **(Valovich McLeod, 2009)[52]**, Dynamic stability (**Holm,etal,2007)[28]** Single limb stability **(Paterno,etal,2004**)[45]Tuck jump (**Brent etal,2010**) [4], etc. were studied.

Studies were also done with focus on improving Vertical jump performance & Agility using training such as Plyometrics (**Goran Markovic, 2007) [16],** Strength training (**Holm etal, 2004) [28]** Combined plyometric &dynamic stretching (**John Shaji,2009)[30].**

Anyone who undergoes a particular training aims at his performance enhancement, as it is the only way to fulfill his/her sports expectation. It is also easy to rate & measure one's performance. In a hurdlers player, the player's performance can easily rated by measuring

his/her vertical jump height & agility, the two components which are considered very important in Basket ball, which is a highly competitive sport.

Plyometric training aims at reducing the reaction time, which directly influences the agility & also the co-ordination which are all components of a proper neuromuscular element. Hence, concentrating on training the Neuromuscular system as a whole rather than focusing on individual components proves effective when it comes for performance enhancement. An individual can perform well if & only if his muscles are strong & flexible. Also, proper balance & neuromuscular control are pre requisite for plyometric drills to be performed**. (Arabatzi F, etal, 2010) [2].**

A neuromuscular training program consists of Stretching, Functional strengthening, Balance training, Plyometrics & Agility training. Hence, this is considered a holistic approach to the neuromuscular system.

This study is aimed at improving the agility and vertical jump performance which are considered the most important elements for rating a Hurdlers player's ability through an integrative NEUROMUSCULAR TRAINING which includes all the components of the neuromuscular system.

3. AIM & OBJECTIVE:-

The aim of this study is mainly focused on performance. It is to find out the effectiveness of a Neuromuscular training in improving the agility and vertical jump performance in Adolescent Male Hurdlers players.

SPECIFIC OBJECTIVES:-

(1) To determine whether a 6- week Neuromuscular training program influences the agility in Hurdlers players.

(2) To determine whether a 6-week neuromuscular training program is able to improve the vertical jump performance in a Hurdlers player.

(3) To find out whether a Neuromuscular training program can bring about improvements in the Agility and vertical jump Performance in Hurdlers players as compared with the group of controls undergoing the Conventional training program.

4. HYPOTHESIS:-

It was Hypothesized that there will be no significant difference between the groups undergoing Neuromuscular training (Group A) and the group undergoing the Conventional training program (Group B) in improving the agility and vertical jump performance in Adolescent Male Hurdlers players.

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5. OPERATIONAL DEFINITIONS:-

NEUROMUSCULAR CONTROL:-

The unconscious activation of the dynamic restraints occurring in preparation for and in response to joint motion and loading for the purpose of maintaining and restoring functional joint stability. It is the interaction of the nervous& the muscular systems to create co-coordinated movement (**William E Prentice, 1999*).***

NEUROMUSCULAR TRAINING:-

Techniques used to alter the speed or magnitude of a muscle contraction by influencing the neural input to the muscle and thereby the output of that muscle, these include, functional strengthening, stretching, plyometrics, Agility training and Balance training (**Myer etal, 2005)**[38]**.**

CONVENTIONAL TRAINING:-

Techniques performed by the hurdlers players prior to their Game as a preparation for the game. These include a warm up consisting of jogging & stretching and other exercises which varies according to teams & coaches.

AGILITY:-

It is the athlete's ability to change direction quickly and appropriately while maintaining maximal speed, balance and power. It requires optimal core strength, balance or body control and flexibility **(Twist & Benickly, 1995**) [45]. Hence, an integrated approach to the neuromuscular element improves agility which is considered important in a jumping and pivoting sport like Basket ball.

VERTICAL JUMP:-

It is the ability to raise one's centre of Gravity higher in a vertical plane solely with the use of one's own muscles, it is a measure of how high an athlete can elevate off the ground from a standstill. Hurdlers and foot ball players are often rated on their jumping abilities, using force from the legs to jump in air (**Jimmy Winslow).**

BASKET BALL PLAYERS:-

Players currently participating in the competitions who are between 12-17 years of Age (high school level players or Adolescents) are defined as hurdlers players in this study. (**Myer et al, 2005**) [38].

6. REVIEW OF LITERATURE:-

1. **Christine Bialkowski, etal, 2006**, in his study, concluded that a Neuromuscular training containing Balance training, strength training & plyometrics may be effective in reducing the incidence of ACL injury. They have recommended the use of a comprehensive neuromuscular training in future on different age groups & to monitor the results. It can also be done separately on males & females [6].

2. **Myer, Gregory D, etal, 2011**, studied the effects of age & its relation with training. In their study they indicated that it is more advantageous to begin neuromuscular training during adolescence (apprx. 12-18 yrs.) to train the body during rapid musculoskeletal growth. Also learning of techniques can be faster and effective during young age than older age [43].

3. Hansel, etal, 2009, in his systematic review, concluded that Proprioceptive & neuromuscular training after ankle & knee injuries can be effective for the prevention of recurrent injuries. It also helps in improving the joint functionality [18].

4. Klaus, etal, 2010, has done a systematic review on neuromuscular training for sports injury prevention. On the basis of seven high quality studies, evidences were found in favour of Proprioceptive/neuromuscular training in reducing certain sports injuries among adolescent and young athletes during pivoting sports [34].

5. Etty Griffin, etal 2003,studied the effects of a neuromuscular training program in the prevention of sports injuries He concluded that Insufficient neurologic input or improperly processing that input at the spinal, brain stem or cognitive centers' can lead to an inadequate motor response resulting in injury. Therefore, it is important to include drills that enhance the neuromuscular control into traditional training, conditioning &rehabilitation programs in sports [13].

6. Christine Bialkowski, etal, 2006, studied about ACL injury prevention programs. They conducted a systematic review, on neuromuscular training & ACL injury prevention**.** The conclusion of this study shows promising evidence that balance/proprioceptive training, strength training & plyometric training when incorporated into a comprehensive training protocol may be effective in reducing the incidence of ACL injuries [6].

7. Inger Holm, etal, 2007, in a randomized study compared the effects of neuromuscular training with that of strength training after ACL Reconstruction.The results of the study suggest that exercises included in the neuromuscular training program should be part of the rehabilitation program following ACL reconstruction [28].

8. Markovic G 2010, studied about the performance enhancement using plyometric training in young athletes. In his study about the Neuromusculoskeletal performance adaptations to lower extremity plyometric training, he concluded that Plyometric exercises help in enhancing the performance by improving the neuromuscular elements[38].

9. Paterno, etal, 2004, in his study found out that a six week Neuromuscular training program designed to decrease the incidence of ACL injuries, improves single limb postural stability in high school female athletes [45].

10. Hewett, etal 2004 found a decrease in neuromuscular control about the knee with maturation in female athletes. They concluded that there exists a difference in the kinetics and kinematics of girls during landing from a jump after maturity. This difference places them at a high risk for ACL injuries [22].

11. Valovich. McLeod, etal, 2009 studied about the balance improvements in female high school hurdlers players after a six week neuromuscular training program**.** The study demonstrated that a neuromuscular training program can increase the balance & proprioceptive capabilities of female high school hurdlers players. They found improvements in both static & dynamic balance. [52]

12. Myer GD, etal 2005, in their study on neuromuscular training & performance in female athletes said that the combination of multitude injury prevention training components into a comprehensive program improves measures of performance & movement biomechanics [42].

13. Hanni R Cowley, etal, 2006 did a study on the differences in neuromuscular strategies between landing & cutting tasks in female hurdlers & soccer athletes. They concluded that Sports specific neuromuscular training be warranted with hurdlers players focusing on jumping & soccer players focusing on unanticipated cutting maneuvers [17].

14. John Shaji, etal, 2009 undertook a study comparing the effects of plyometric training program & dynamic stretching on vertical jump & agility in male collegiate hurdlers players. The findings of this study suggest that 2 days of plyometric training a week in combination with dynamic stretching for four weeks is sufficient enough to show improvements in vertical jump & agility in hurdlers players. On the other hand dynamic stretching alone is less effective in improving vertical jump among the hurdlers players[30].

15. Michael G Miller, etal 2006, reported that plyometric training can be an effective training technique to improve an athlete's Agility. It helps in improving the readiness of an athlete & prepares him for the movement. It improves the agility by targeting the anticipatory response [17].

16. Hubscher M, etal, 2010, on the basis of the results of 7 high quality studies, in a systematic review showed evidence for the effectiveness of proprioceptive neuromuscular training in reducing the incidence of sports injuries among adolescent & young athletes during pivoting sports [25].

17. Zazulak B, etal, 2008, suggested the: clinical implications for sports injury prevention through developing neuromuscular control of trunk stability. Current perspectives of neuromuscular learning can be applied clinically to aid in the formulation of injury prevention strategies [57].

18. Matavulgi D, etal, 2001, performed a study on junior level hurdlers players targeting their jump performance. It was proved that a limited amount of plyometric training could improve jumping performance in elite junior hurdlers players and this improvement could be partially related with an increase in maximal voluntary force of hip extensors & the rate of force development of knee extensors.

19. Christena W. Ford, 2005, analyzed the effects of a six week neuromuscular training program in reducing the reaction time of the peroneus longus muscle in healthy adults. Neuromuscular training program may have a beneficial effect on improving the activation of dynamic restraints during activity [5].

20. Limpis vastio, 2005, used Vertical jump as a tool in assessing muscular power & anaerobic performance. He concluded that muscular strength & anaerobic power could be assessed by single & multiple vertical jump testing procedures. It proves an easy yet effective way of evaluating a players' initial level of fitness [65].

21. Chappell JD, etal, 2008, studied the effects of a Neuromuscular training program on the kinetics & kinematics of jumping tasks. They reported that a neuromuscular training program can alter motor control strategies. Younger athletes may benefit more from a neuromuscular training program because motor control strategies are not yet as firmly established [31].

22. Goron Markovic, 2007, performed a meta-analysis on plyometric training & its influence on vertical jump. The results of this investigation support previous narrative reviews that plyometric training is effective in improving the vertical jump [16].

23. Kati Pasanen etal, 2008, evaluated the incidence of leg injuries among female floor ball players & concluded that neuromuscular training helps in reducing the injury risk among female floor ball players. They suggested that a neuromuscular training program enhances the motor skills & body control of female floor ball players & reduced the risk of leg injuries by 66%. Hence it is recommended that a Neuromuscular training program should be included in the weekly training program of floor ball to reduce the incidence of non-contact injuries [33].

24. Adams et al., 1992, in his study said that from a physiological and psychological standpoint, four to six weeks of high intensity power training is an optimal length of time for the CNS to be stressed without excessive strain or fatigue. He also stated that it is the belief of some sports physiologists that neuromuscular adaptations contributing to explosive power occur early in the power cycle of the per iodization phase of training [1].

25. Myer GD, Ford KR, Palumbo JP, Hewett TE, 2005, recommended that a neuromuscular training improves performance and lower-extremity biomechanics in female athletes & hence should be included in their training schedule. The results of this study support the hypothesis that the combination of multiple-injury Prevention-training components into a comprehensive program improves measures of performance and movement biomechanics [42].

7. METHODOLOGY:-

7.1 STUDY DESIGN: - Quasi - Experimental study.

7.2 STUDY SETTING: - YMCA
St.VINCENT SCHOOL

7.3 STUDY POPULATION: - Hurdlers players.

7.4 STUDY DURATION: - 6-WEEKS

7.5 SAMPLING DESIGN: - Purposive sampling

7.6 SAMPLE SIZE: - 30 Adolescent, male hurdlers players.

7.7 SAMPLING CRITERIA:-

INCLUSION CRITERIA:- All subjects should be screened off for any previous injuries, for the past 6 months.

(i) Healthy (with no systemic illness), male hurdlers players matched for age, height and Sizes are selected and randomly allocated to group A , undergoing neuromuscular training & group B undergoing the conventional training.

(ii) Age = 12 to 17 years.

(iii) Currently participating in high school competitive hurdlers.

(iv) Agility-Poor (>11.5 seconds) [64].

(v) Vertical jump height >30cms. & <50cms. (Below average & average criteria)[63].

(vi) Off-season players.

EXCLUSION CRITERIA:-

(i) Previously injured (within 6 months), Unco-operative, less motivational subjects are excluded.

(ii) Subjects who are undergoing previous neuromuscular training or other training such as Plyometric training are excluded.

(iii) Limb length discrepancy.

(iv) Previous surgeries to lower limb.

(v) Neuromuscular weakness.

(vi) Ligament instability in lower limb.

(vii) Back injury.

(viii) Recreational players.

(ix) Subjects playing sports other than hurdlers.

7.8 VARIABLES:-

INDEPENDENT:-

(i) NEUROMUSCULAR TRAINING.

(ii) CONVENTIONAL TRAINING

DEPENDENT:-

(i) AGILITY.

(ii) VERTICAL JUMP PERFORMANCE.

7.9 OUTCOME TOOLS:-

(i) AGILITY: - Measured using T-Test for Agility.

(ii) VERTICAL JUMP: - Measured using Vertical jump Test.

8. PROCEDURE:-

8.1 SAMPLING PROCEDURE:-

Thirty Adolescent male hurdlers players were selected through purposive sampling as per the inclusion criteria. All were explained about the study procedure and asked to sign an informed consent form prior to group assignment. Then, they were randomly allocated into two groups, GROUP A & GROUP B. The characteristics and demographics for the subjects in both the groups were similar.

GROUP A underwent the Neuromuscular training program and GROUP B participated in the Conventional training program. GROUP A consisted of 15 participants; GROUP B consisted of 15 participants. Both the groups were blinded from the training they underwent. That is they were not aware of the training of the other group.
The descriptive statistics of the subjects in the study are tabulated (**Table: 1**). The mean age of the subjects was 14.3±1.4, and 14.5±1.5 in the GROUP A & GROUP B, respectively.

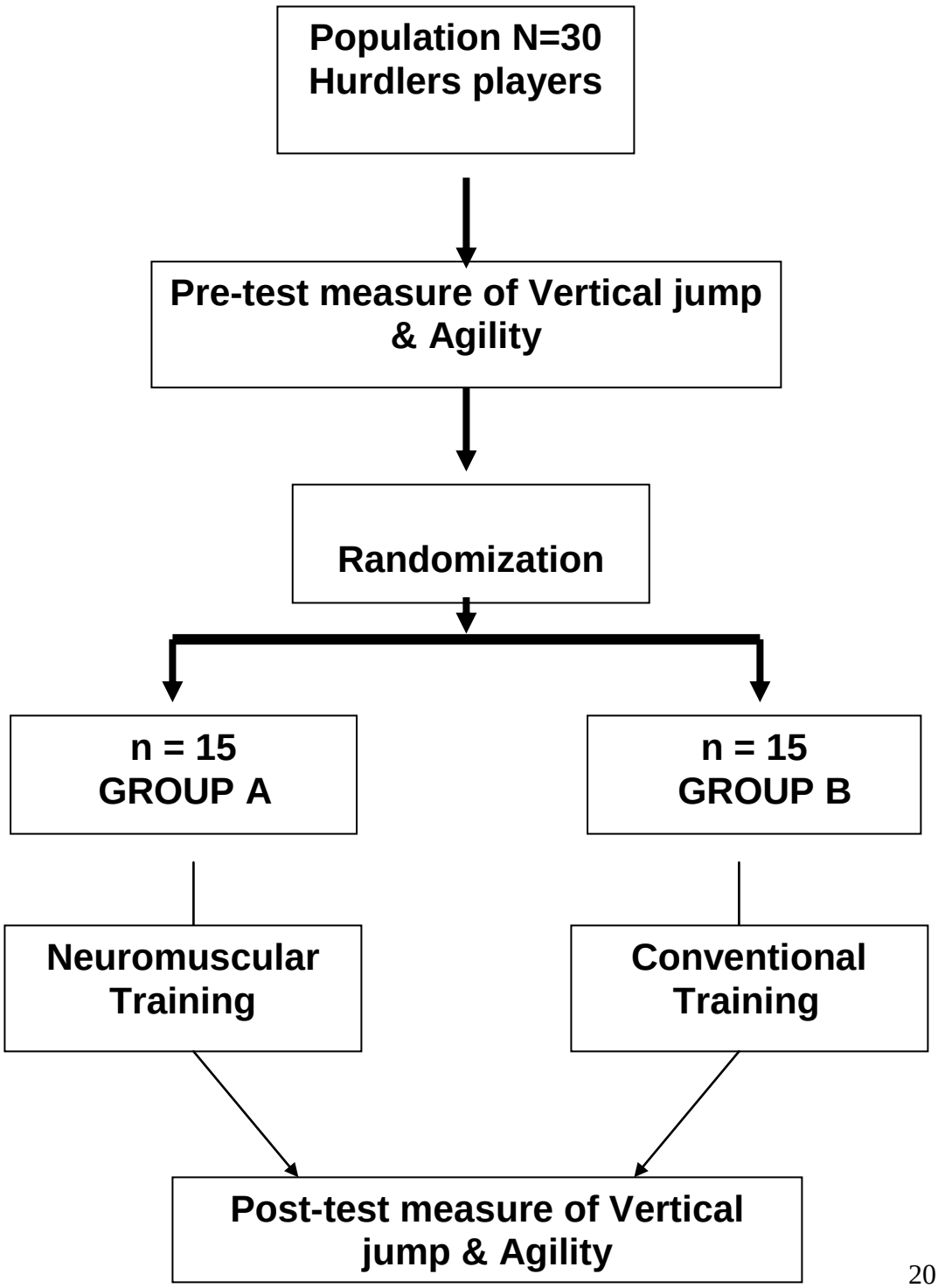
Table 1 showing descriptive statistics for subjects participating in the study

Feature	Group A	Group B
Age (mean± sd)-years	14.3±1.4	14.5±1.5
Mean Height (cm)	150.7±8.1	151.5±6.8
Mean Weight (kg)	48.9±5.9	52.±6.4

GROUPA was the EXPERIMENTAL group & GROUP B was the CONTROL group. As a pre-study procedure, initial assessment was conducted and the subjects were evaluated at their baseline for their VERTICAL JUMP using vertical jump test & AGILITY using T - test. Their pre-test values were recorded. Then training was given according to the protocols for each group for six weeks, 2- sessions per week. The post-test scores were

recorded after six weeks. The mean & standard deviation for both the pre-test & post-test scores were calculated and analyzed.

FIGURE 1. FLOW OF PARTICIPANTS THROUGH EACH STAGE OF THE STUDY



8.2 PROCEDURE FOR OUTCOME MEASURES:-

PROCEDURE FOR VERTICAL JUMP TEST

Figure 2: Reach position for vertical jump test

Figure 3: Subject performing vertical jump test

Materials: Measuring tape, chalk/marker for marking wall.

Purpose: The vertical jump test involves measuring the difference between the standing reach and the height reached at the peak of a vertical jump.

Procedure: The player stands side on to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips is marked or recorded. This is called the standing reach height. The athlete then stands away from the wall, and leaps vertically as high as possible using both arms and legs to assist in projecting the body upwards. Attempt to touch the wall at the highest point of the jump.

The difference in distance between the standing reach height and the jump height is the score. The best of three attempts is recorded.

Reliability: Vertical jump reliability has been reported to range between 0.90 and 0.99 (**Zachazewski J.E., etal, 1996)** [49].

PROCEDURE FOR AGILITY T-Test

Materials: Measuring tape, 4 Marking cones, Stop watch

Purpose: The T-Test is a test of agility for athletes, and includes forward, lateral, and backward running

Procedure: Set out four cones as illustrated in the diagram above (5 yards = 4.57 m, 10 yards = 9.14 m). The subject starts at cone A. On the command of the timer, the subject sprints to cone B and touches the base of the cone with their right hand. They then turn left and shuffle sideways to cone C, and also touch its base, this time with their left hand. Then shuffling sideways to the right to cone D and touching the base with the right hand. They then shuffle back to cone B touching with the left hand, and run backwards to Cone A. The stopwatch is stopped as they pass cone A. The time taken to complete the test is recorded & compared with the post-test value.

Reliability: Good test-retest reliability, Validity and reproducibility of the test has been reported. (**Pauole et al., 2000; Roozen, 2004)** [42].The intraclass reliability of T-test is 0.98 across 3 trials.

Figure: 4 Agility T-test

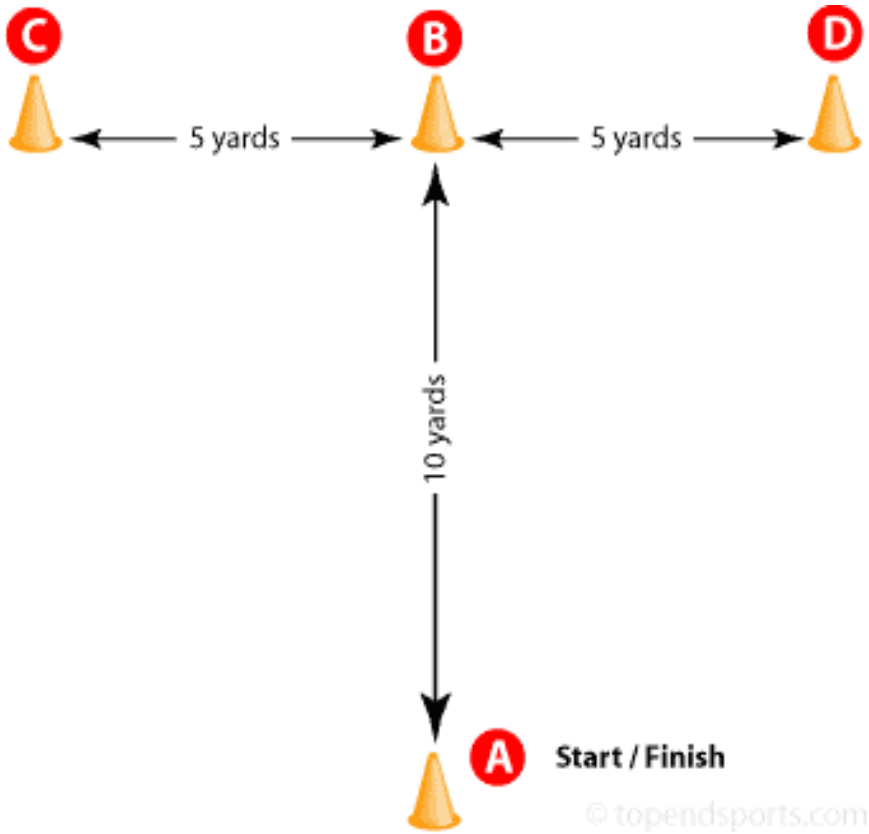


Figure: 5 Subject performing T-Test

8.3 PROCEDURE FOR TRAINING PROGRAM

GROUP A was trained with the NEUROMUSCULAR TRAINING PROGRAM which consisted of 2-sessions / week for 6-weeks, each session lasting for one and half hours before the start of the hurdlers season (off-season).

During the training session, participants began with a 5-minute warm up consisting of Jogging, side shuffles & Stretches.

1. Stretching Exercises - Hold time-30 seconds, 1-2 repetitions **(Figure 6.1-6.5)**

- Hamstrings Stretch-Sitting & Standing,
- Quadriceps-Standing
- Glutei Stretch - Standing
- Psoas Stretch
- Tibialis anterior Stretch
- Calf Stretch
- Abdominal Stretch

Subjects then rotated through 4 different stations including Functional strengthening (30 minutes), plyometrics (20 minutes), agility training (10 minutes), and balance training (10 minutes). The following exercises were performed during the training sessions.

FIGURE 6 STRETCHING EXERCISES

Figure 6.1 Psoas stretch

Figure 6.2 Sitting Hamstring stretch

Figure 6.3 Glutei stretch

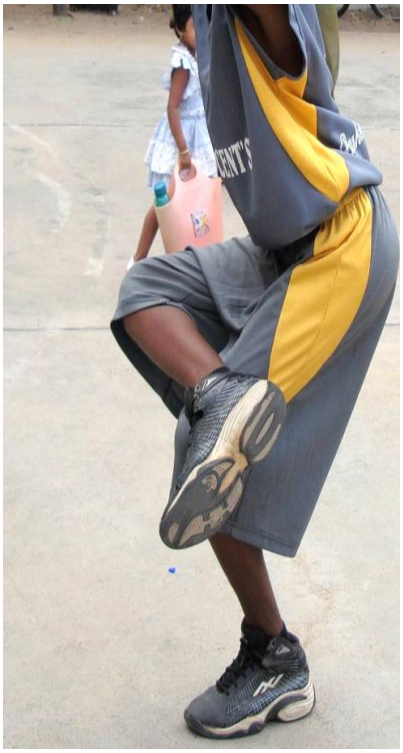


Figure 6.4 Quadriceps stretch

Figure 6.5 Calf stretch

2. Functional Strengthening-30 minutes, each exercise done for 10 to 15 reps **(Figure 7.1-7.4)**

- Double leg Squat
- Single leg Split Squat
- Push ups
- Isometric Side Bridge
- Iron man
- Lunges
- Half squats
- Dribbling the ball

3. Balance & Body control Exercises – 3 to 10 repetitions **(Figure 8.1-8.4)**

- Double leg Balance – Ready position 3×30 secs
  Ready position with ball passing 3×30 secs
- Single leg balance 3×15 secs for each leg
- Double leg squat on ground- 10 reps
- Single leg Squat on ground- 5 reps for each leg
- Double & single leg ball passes on core board – 5to 10 reps
- Double leg Squat on Core board -10 reps
- Single leg Squat on Core board -5 reps for each leg
- Squat with Medicine ball on Core board -5 reps

FIGURE 7 FUNCTIONAL STRENGTHENING EXERCISES

Figure 7.1 Lunges

Figure 7.2 Push up

Figure 7.3 Half squatting

Figure 7.4 Ball Dribbling

FIGURE 8 BALANCING EXERCISES

Figure 8.1 Single leg balance

Figure 8.2 Double leg on Core board

Figure 8.3 Ready position

Figure 8.4 Balancing with Medicine ball

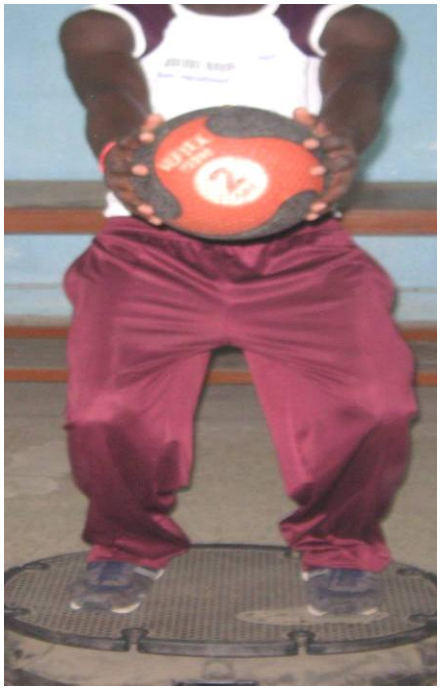
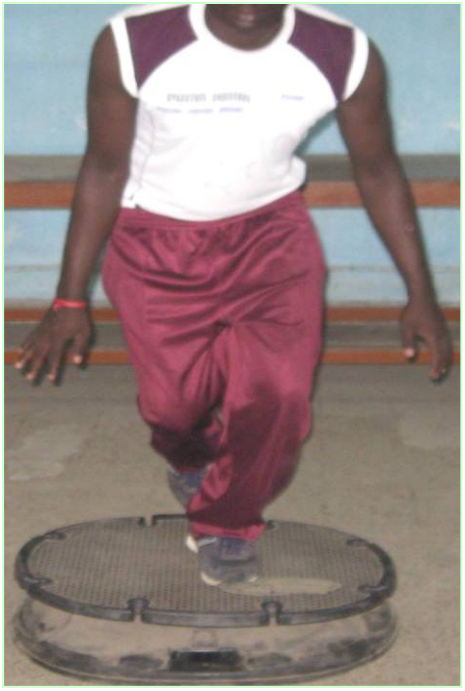


Figure 8.5 Single leg squat on core board



4. Plyometric Exercises – 5 to 7 repetitions **(Figure 9.1-9.6)**

These are explosive and help to build, power, strength and speed.

- Ankle jumps
- Tuck jumps
- Squat jumps
- Cone jumps- Forward & sideways
- Lateral hops over cone
- Forward & backward hops over cone
- Single leg Hops for distance

5. Agility Exercises (Figure 10.1-10.4)

These are designed to improve the power & strength in the muscles.

- Cone Figure 8 Forward running – Up & back twice (increase width weekly)
- Shuttle run – Forward &Backward -2 repetitions each
  Lateral side -2 repetitions
  M pattern & W pattern – 2 times each direction
- Line jumps – Double leg Forward & backward - 2 repetitions
- Split Squat jumps – 3 repetitions for 30 seconds each
- Weave in & out using cones
- Box drll

Exercises at each station were progressed weekly by increasing the number of repetitions, time spent or the difficulty of exercise. The exercise protocol was derived from those given by Tamara etal 45, 2009, The jump training manual for Basket ball, Brian Mac Sports coach- Book for Fitness training (U.K.)

FIGURE 9 PLYOMETRIC EXERCISES

Figure 9.1 Depth jump
Starting position

Figure 9.2 Subject performing
Depth jump

Figure 9.3 Split squat jump

Figure 9.4 Tuck jump

FIGURE 9 PLYOMETRIC EXERCISES

Figure 9.5. Front cone jump

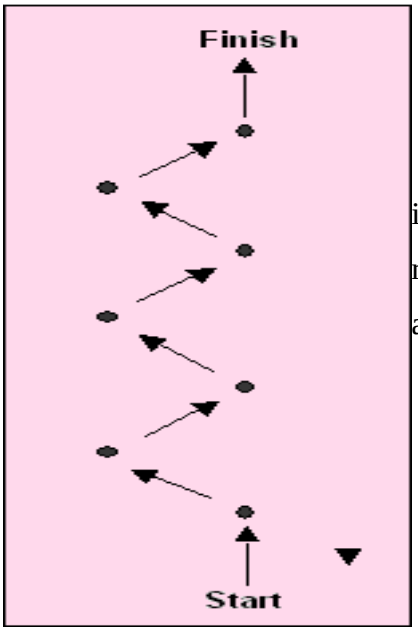
Figure 9. 6 Side cone jump

FIGURE 10 AGILITY EXERCISES

Figure 10.1 Shuttle runs

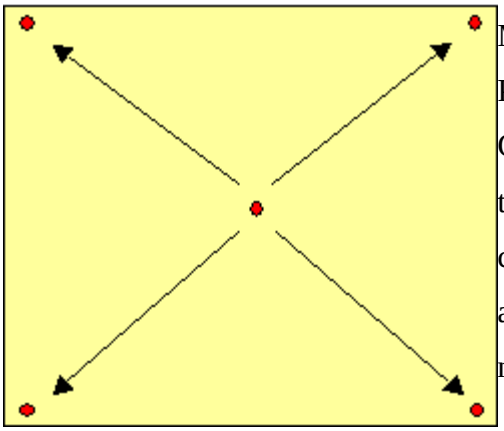
Figure 10.2 Zigzag running

Figure 10.3 Weave in & out



Place 4 cones 3 meter apart. Place 3 more cones intersecting the previous cones 3 meters apart. The subject runs through the cones in the direction as shown by the arrows.

Figure 10.4 Box drill



Mark out a square approximately 6 yards X 6 yards. Place a cone in the center. This is the starting position. Give each cone a letter or number. The coach calls out the number/letter at random. The player sprints to the cone and shuffles back to the center. As soon as they arrive at the center, the coach calls another number/letter. Repeat for 60-90 seconds.

GROUP B was trained with the Conventional training program (**Figure 11.1-11.6**) consisting of warm up (jogging) & stretching for upper &lower limbs (Triceps, Biceps, Trapezius, Quadratus lumborum, quadriceps, Hamstrings & Calf).

- Running around the ground
- Lunge walking
- Dribbling with the hurdlers
- Passing the ball with a partner
- Single & double leg hops

The training session
lasted for one hour. During the six week period they were instructed not to change their routine training and to continue their regular practice sessions. They were also instructed not to add up any new exercise program to their usual schedule.

At the end of the training session both the Groups performed a cool down consisting of:

- Slow running
- Stretching to large muscle groups (glutei, quadriceps, Hamstrings, calf)

FIGURE 11. CONVENTIONAL TRAINING PROGRAM

Fig.11.1 Arm swing

Fig 11.2Trunk stretch

Fig 11.3 Running

Fig 11.4Running with ball

Fig 11.5 Ball Dribbling

Fig11.6 figure 8 dribble

9. STATISTICAL ANALYSIS:-

All analyses were performed using SPSS software. Data were recorded. The pre-test and post-test scores were taken & the functional outcome evaluated for both the groups. Descriptive statistics such as mean & standard deviation were used for data analysis & Inferential statistics was used for comparing the pre-test & post-test scores within the groups and between the groups.

STATISTICAL TOOL

Paired t-test was used to find out the difference in the pre-test & post-test scores within the groups.

Formula: Paired t-test

$$S = \sqrt{\frac{\sum d^2 - \frac{(\sum d)^2}{n}}{n-1}}$$

$$t = \frac{\overline{d}\sqrt{n}}{s}$$

Where,

d = difference between the pre test versus post test

$\overline{d}$ = mean difference

n = total number of subjects

s = standard deviation

Unpaired t-test was used to compare the mean difference between Group A and Group B.

Formula: Unpaired t-test

$$S = \sqrt{\frac{\sum (X_1 - \overline{X_2})^2 + \sum (X_2 - \overline{X_2})^2}{n_1 + n_2 - 2}}$$

$$t = \frac{\overline{X_1} - \overline{X_2}}{S} \sqrt{\frac{n_1 n_2}{n_1 + n_2}}$$

Where,

$\overline{x_1}$ = Mean of Group A

$\overline{x_2}$ = Mean of Group B

$\sum$ = sum of the value

n_1 = number of subjects in Group A

n_1 = number of subjects in Group B

S = standard deviation

Level of significance: 1% $p \leq 0.01$

The mean and Standard Deviation values of pre-test and post test measurements of vertical jump test for group A and group B are recorded in Table 2. The mean and Standard Deviation values of Agility T-test for the groups A & B are recorded in Table 3. The mean difference & Standard Deviation for Vertical jump test & Agility T-test between the groups A & B are recorded in table 4.

Analysis was done using ***unpaired t-test*** to derive the significance (2- tailed), i.e.
p- Value between the group and ***paired t-test*** for comparison within the group. The level of significance ($P \leq 0.01$), was calculated from the mean & Standard Deviation.

The Pre-test & Post-test values for VER TICAL JUMP TEST for both GROUPA & GROUP B are tabulated below(Table 2). The mean difference for pre & post –test scores show significant difference for both the groups which indicates that there is a significant increase in the vertical jump performance after training in both groups A & B. The paired t-value for Group A is 17.27 & for Group B is 13.16. The values are greater than the table values signifying the effects of training which has altered the pre & post test scores.

TABLE 2: showing mean, standard deviation, mean difference, t-test, significance for Vertical jump test within the groups

VERTICAL JUMP TEST	PRE-TEST		POST-TEST		Mean difference	t-Value	Significance
	MEAN	SD	MEAN	SD			
GROUP A	39.66	1.87	44.33	1.75	4.67	17.270	0.000**
GROUP B	40.33	2.22	43.60	1.63	3.27	13.163	0.000**

** ($p \leq 0.01$) is statistically significant

TABLE 3: showing mean, standard deviation, mean difference, t-test, significance for Agility T-test within the groups

AGILITY T-TEST	PRE-TEST		POST-TEST		Mean difference	t-Value	Significance
	Mean	SD	Mean	SD			
GROUP A	12.95	0.71	12.08	0.69	0.87	15.243	0.000**
GROUP B	12.91	0.59	12.76	0.57	0.14	4.036	0.001**

** ($p \leq 0.01$) is statistically significant

TABLE 4: showing mean difference, standard deviation, t-test, significance of Vertical jump test (VJ) & Agility (AG) between the groups

VARIABLE FOR GROUPS	MEAN	SD	MEAN DIFFERENCE	t-Value	SIGNIFICANCE
VJ TEST GROUP A	4.67	1.04	1.40	3.816	0.001**
GROUP B	3.27	0.96			
AGILITY GROUP A	0.87	0.22	0.73	10.710	0.000**
GROUP B	0.14	0.14			

** (P< 0.01) is statistically significant

Figure 12 Bar diagram showing Pre & Post test values of Vertical jump within the groups

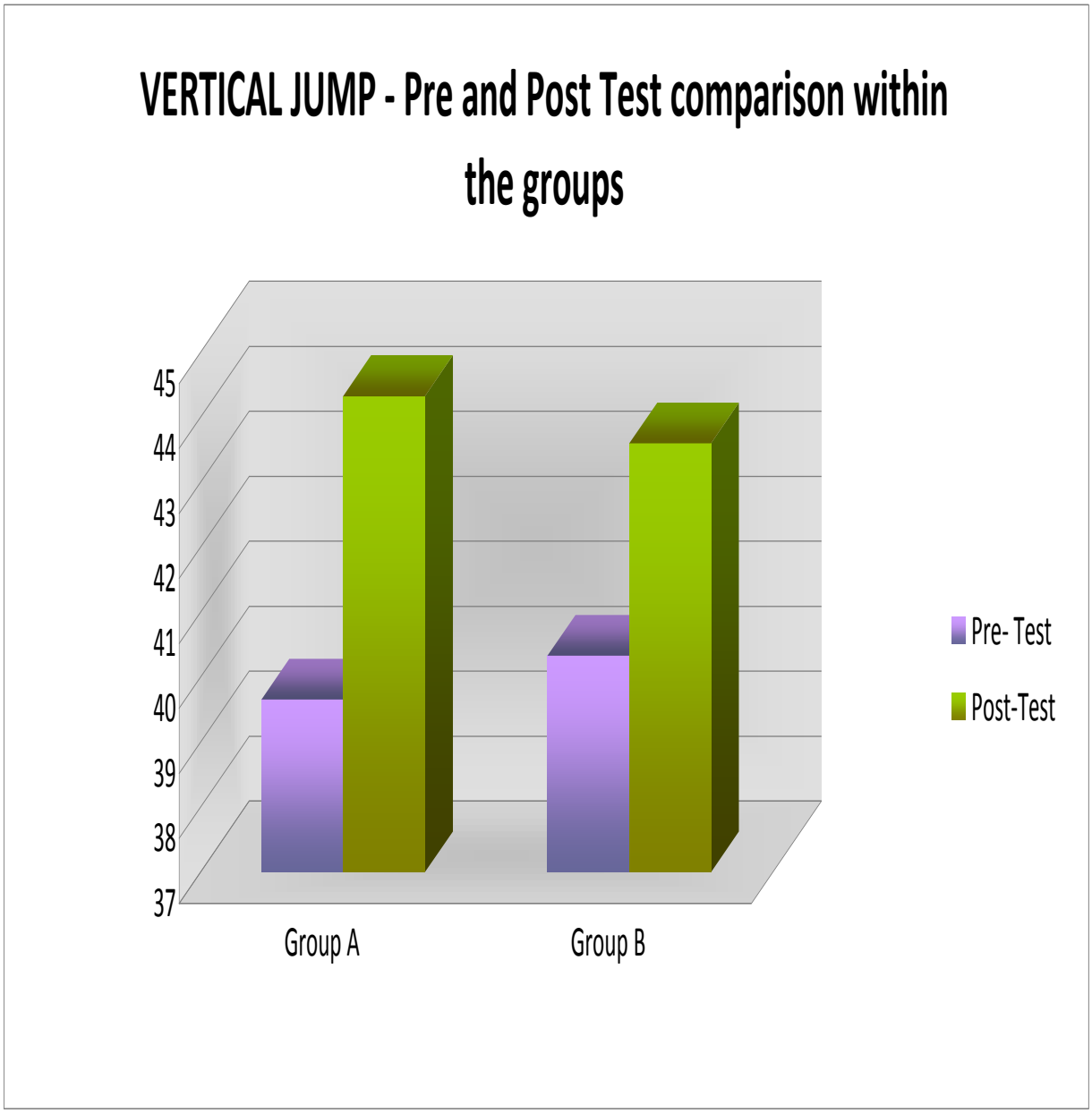


Figure 13 Bar diagram showing Pre & Post test values of Agility T-test within the groups

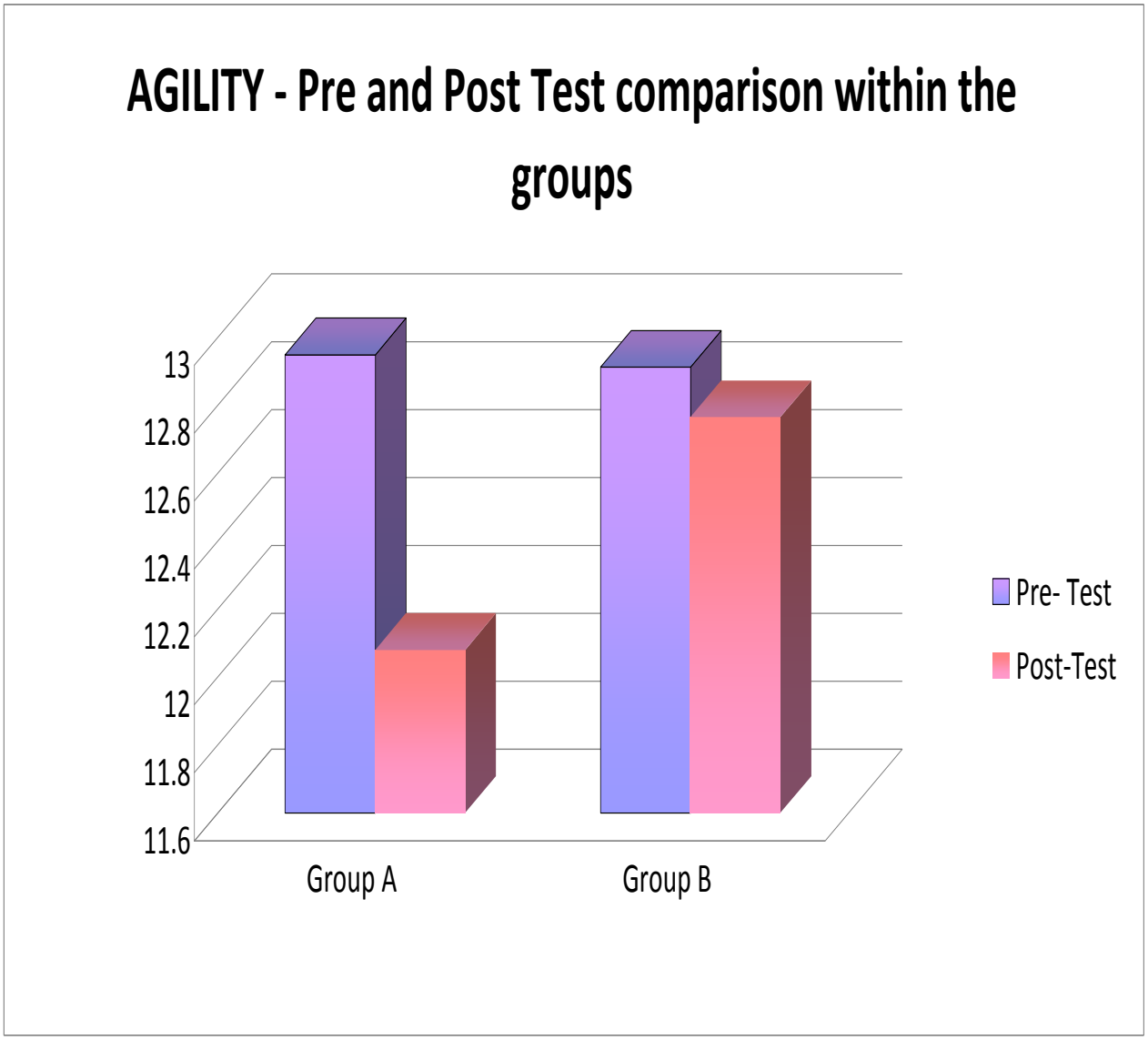


Figure 14 Bar diagram showing differences for vertical jump between the groups.

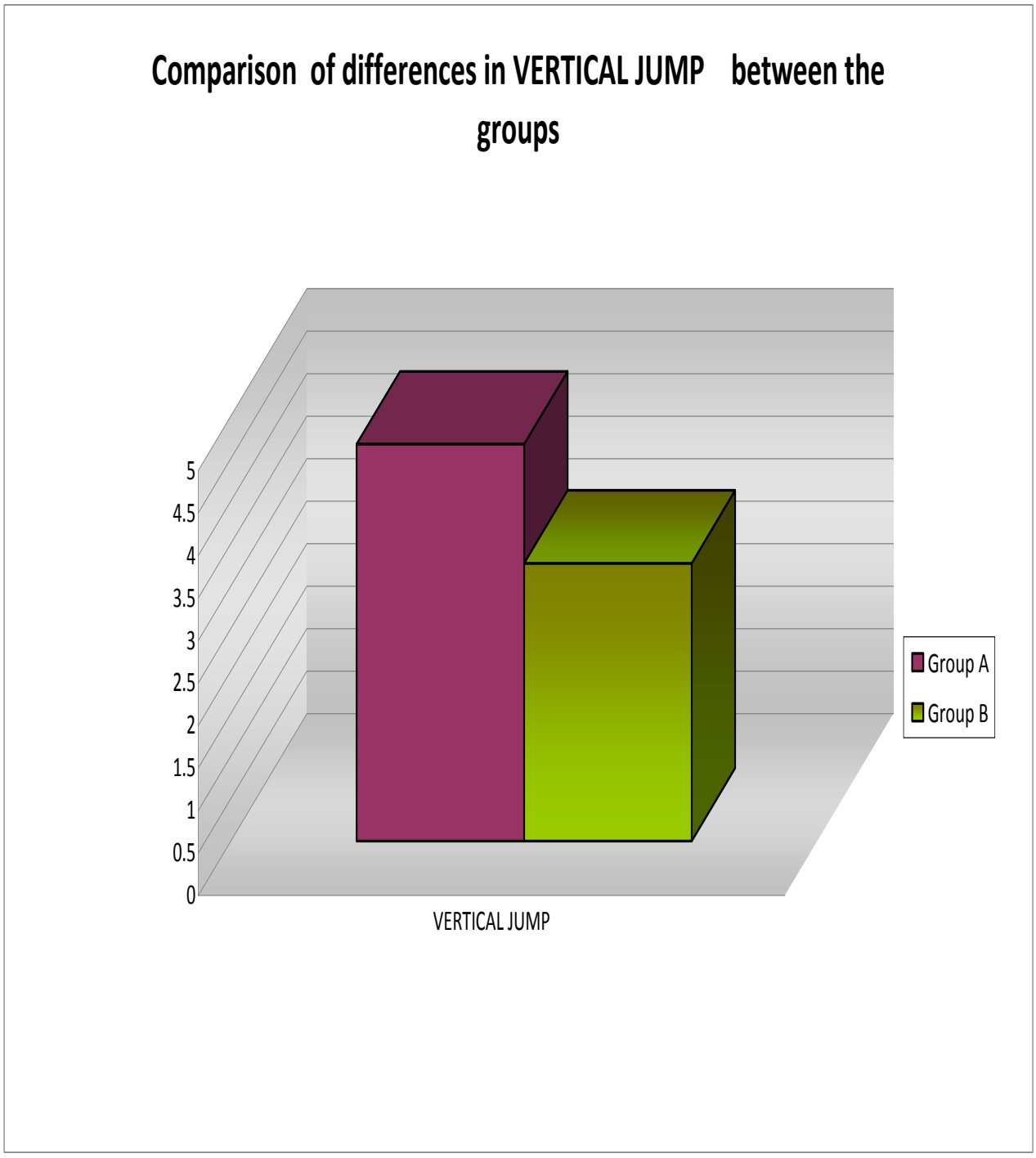
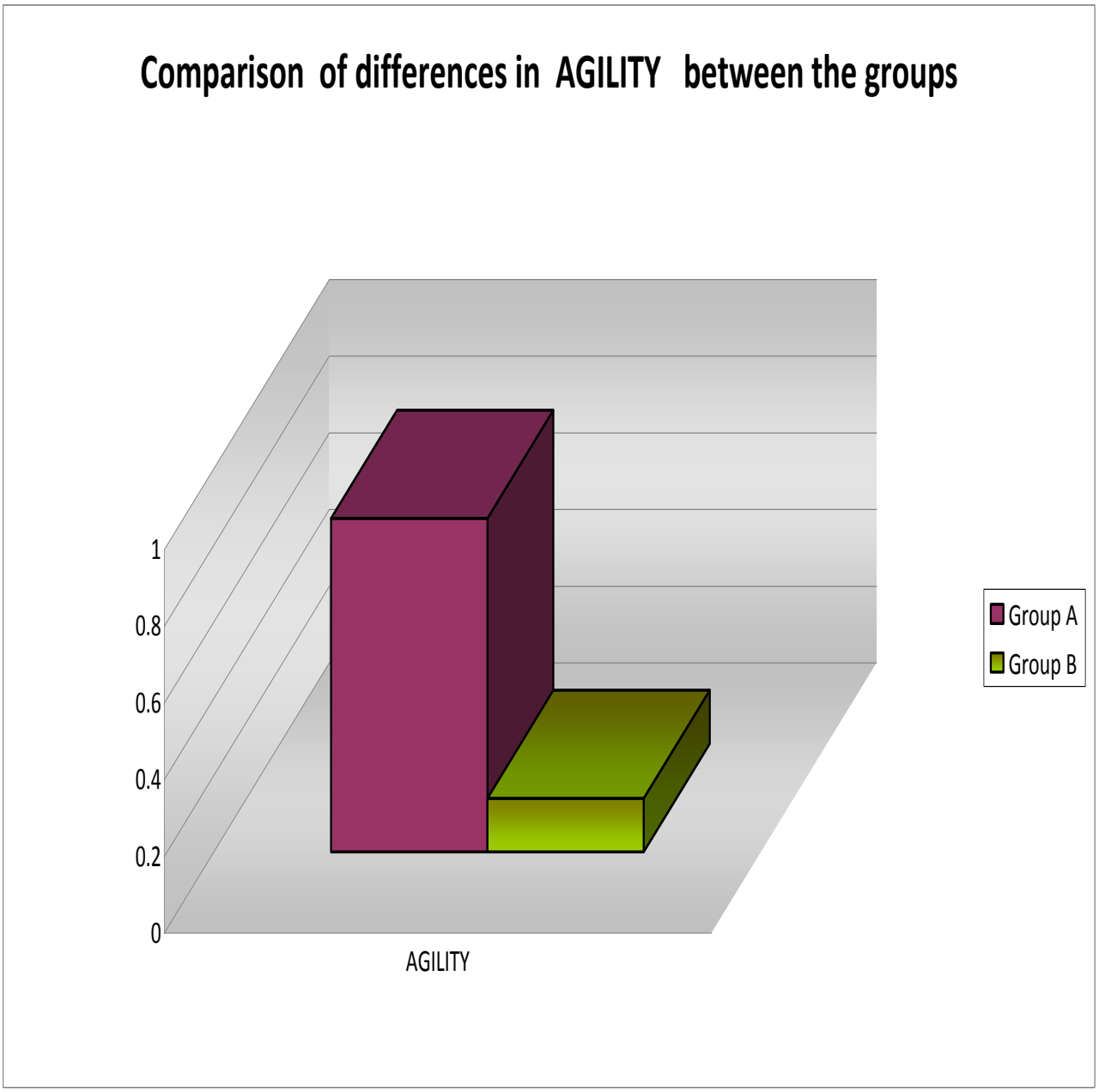


Figure 15 Bar diagram showing differences for agility between the groups.



10. RESULTS:-

By comparing the results obtained from the Paired t-test there is significant increase in the vertical jump test & agility T-test between the Pre-test & Post-test values for both Group A & Group B at p value $\leq$ 0.01.

Table 2 shows the Pre & Post test scores for VERTICAL JUMP TEST for Group A & Group B. The mean difference between the pre & post scores for vertical jump for Group A is 4.67 & for Group B is 3.27. The paired t-value for Group A is 17.27 & for Group B are 13.16. Both these values are greater than the table value at 1% level of significance p= 0.000**which indicates that there is statistically significant improvement for vertical jump height after training for both the groups.($p \leq 0.01$ is statistically significant).

Table 3 shows the Pre & Post test scores for AGILITY T-TEST for both the Groups A & B. The mean difference between the pre & post test scores indicates that there is reduction in the time taken to complete the T-test after training (i.e., after six weeks). The mean difference for Agility T-test score between the Pre-test & the Post-test scores are 0.87 for Group A & 0.14 for Group B. The paired t-value for group A is 15.24 & for group B is 4.03. The significance value is p= 0.000** for Group A & 0.001** for Group B which is statistically significant.($p \leq 0.01$) The values are greater than the table values which indicates that there is significant difference between the pre & post test scores as a result of training.

The table 4 shows the mean difference for the variables VERTICAL JUMP & AGILITY T-TEST for both the groups. These values are compared by means of the Independent sample test or otherwise called the UNPAIRED t- TEST.

The Unpaired t-value for the vertical jump test is 3.816 between the groups. This is greater than the tabulated value at 1% level of significance, p=0.001**, indicating that there is a statistically significant ($p \leq 0.01$) difference between the groups after training for the vertical jump test. This shows Group A showed better improvement in vertical jump than Group B.

The Unpaired t-value for AGILITY T-TEST between the groups is 10.71 which is more than the table value at 1% level of significance, p=0.000**, which is statistically highly significant ($p \leq 0.01$). This indicates that Group A has improved better than Group B showing highly significant reduction in the time taken to complete the T-test for Agility.

Both the above results indicate that Group A which underwent the NEUROMUSCULAR training program showed significant improvement in both the VERTICAL JUMP & AGILITY than Group B which underwent the usual training. This shows that the NEUROMUSCULAR TRAINING PROGRAM is effective in improving the vertical jump & agility among the hurdlers players than the conventional training.

Hence, the Hypothesis Formulated stating that there will be no significant difference between the groups undergoing the Conventional training & the neuromuscular training program is rejected.

11. DISCUSSION:-

Thirty subjects who were all hurdlers players participated in the study; 15 in the group A & 15 in the group B. Pre-test scores for vertical jump & agility were measured & recorded using vertical jump test & T-test for both the groups. The measurements were taken by an observer who was unaware of the training each group underwent.

After taking the baseline values, the participants underwent the training as per the protocols described in the procedure for six weeks. At the end of the sixth week, post-test scores were taken & recorded. The results were statistically analyzed using paired & unpaired t-test at 1% level of significance.

There was significant improvement in the performance as measured by vertical jump test & agility T-test in the Neuromuscular training group A compared with the Conventional training group B. The result demonstrated t hat the vertical jump height readings for the vertical jump test was improved by 4.67 cm in the Group-A and 3.27 cm in the Group-B ($p \leq 0.01$). This may be due to the neuromuscular adaptations as studied by **Markovic et al [38], 2010.** Also, the change in the biomechanics during jumping & landing may be attributed to the neuromuscular training leading to better neuromuscular control (**Kati pasanen, 2008) [31].**

The T-test agility score time was reduced by 0.87 in the Group-A & 0.14 for the Group- B ($p \leq 0.01$) because of better motor recruitment or neural adaptations. (**Michael G Miller, 2006) [17].**

The improvements achieved were the result of enhanced neuromuscular function. The occurrence of 'post activation potentiation' is believed to increase the rate of forcedevelopment, thereby increasing speed and power production as per **Sale D et al**, **2002**. It has also been postulated by **Faigenbaum et al [53]**, **2011** that vertical jump height enhanced due to excitability of fast twitch motor units. However, no test was conducted for the detection of neuromuscular activation or improved biomechanical function.

As studied by **Chapel JD etal, 2008** [31], the neuromuscular training can alter the motor control strategies that alters the kinetics & kinematics of the knee during jumping & landing. This may also help in reducing the ground contact time which in turn influences the speed & agility of the player.

Part of the training program consisted of Balance related activities that constantly increased in difficulty. The exercises progressed from balancing on the ground to balancing on the core board & added activities such as squats, ball passing, & dribbling which increasingly stressed the Motor control system and provide greater neuromuscular control challenges. This has resulted in better balance control during cutting, jumping & landing activities. (**Valovich Mc Leod, 2009)** [52]**.**

In addition, the functional strengthening exercises performed during training improved the strength of the lower extremity which also contributed to increase in anaerobic power of the limb. This increase in power improved the vertical jump performance (**Myer etal, 2007)** [41]**.**

The stretching exercises performed during training has improved the flexibility of the muscles of the trunk, hip, and knee which also helped in better execution of movements during vertical jump & T-test.

For agility to improve the speed & magnitude of muscle contraction should improve. Plyometric training undergone in t he neuromuscular training group helped in reducing the reaction time through the better ability of the muscle to contract after a stretch which acts as a preparatory phase for the movement to occur. (**Goran Markovic, 2007)** [16]**.**

Many studies have indicated that neuromuscular training probably plays a crucial part in the prevention of lower limb injuries (**Ekstrand, etal, 1983, Hewett, etal** [20]**, 1999, McGuine, etal** [39]**, 2006, Kujala, etal, 2007).** This s tudy focused o n the performance aspect of the hurdlers players and have proved to be effective in improving the players' performance (measured by vertical jump & agility). The program also focused on improving the motor

skills & body control as well as preparing the neuromuscular system for sports specific maneuvers which also helps to enhance performance (**Kati Pasanen, etal, 2008**)[31].

The main emphasis of this program was on proper techniques with good posture during jumping & landing activities. The main aim was position of the hip & knee maintained over the toes. By performing the exercises in a group postural correction was made easier. This program focused mainly on performance enhancement which would add up better compliance from the player's side. Better participation also would have yielded improved performance.

The increase in the anaerobic power although not measured in this study, shows improvements in the vertical jump &agility through increased fast twitch muscle fibers**. (Myklebust, etal, 2006)** [44]

All the above discussed factors have holistically improved the performance of the hurdlers player. The result obtained is increased vertical jump height & agility which is more significant in the Group A than the Group B showing the effectiveness of the neuromuscular training program.

12. LIMITATIONS & RECOMMENDATIONS:-

This study had some Limitations .Firstly, the study was not Randomized and the potential for not achieving double-blinding limits the strength of this study.

Next, the study sample was too small for a population of Hurdlers players which limits its generalization. Similar study can be performed on a large sample over an extended period of time to find out the causal relationship.

There were certain exercises which were similar in both the Groups such as stretching exercises, control over which was not achieved. This could have influenced the results obtained in the control group.

There were no measures taken to address the other components of the Neuromuscular training program, the Balance, Proprioception, and Strength & Flexibility. Future studies can be done with emphasis on these components to find out the influence of training on them.

This study was focused on the performance enhancement among the hurdlers players in an off-season. Future studies can be performed as Prospective studies to find out the effects of neuromuscular training in improving performance on a long-term basis.

It can also be incorporated in the training schedule of players of other sports such as baseball, volley ball, hand ball, hockey, soccer, etc., tailored to fit their sport with special emphasis on the techniques to find out whether it can be effectively used in enhancing performance in them.

The environmental factors might also have influenced the study. Hence, control over the extraneous variables need to be considered.

Simple measures such as Vertical jump & Agility T-test were used for evaluation in this study. Other reliable & valid outcome measures like biomechanical analysis, force platform, EMG analysis, Isokinetic device Etc., can be used in future studies for more accurate & precise calculation using which it can be strongly recommended to include an effective Neuromuscular training program in the regular practice schedule of hurdlers players as a measure of enhancing performance.

This study was carried out on male adolescent hurdlers players. It can also be done in different age groups to find out whether age can influence the changes brought about in the performance. Also, it can be incorporated in the training of female hurdlers players to find out the effects of Neuromuscular training in them.

13. CONCLUSION:-

The results obtained from this study shows significant difference for neuromuscular training in the performance of hurdlers players as measured by the vertical jump & T-test for agility. The mean difference for vertical jump showed significant increase between the pre-test & post-test scores for both the groups with highly significant increase in the Experimental group as compared with the control group. Similarly, the mean difference for T-test for agility showed reduction in the timing which was more significant for the Experimental group than the Control group.

From the above results it can be concluded that a six weeks neuromuscular training program is effective in improving the **vertical jump performance & agility** among the hurdlers players. Hence it can be recommended that an integrative neuromuscular program consisting of FUNCTIONAL STRENGTHENING, STRETCHING, PLYOMETRICS, AGILITY TRAINING & BALANCE TRAINING proves effective, useful & performance oriented rather than the usual training program. Hence inclusion of a neuromuscular training program enhances the performance among the adolescent hurdlers players.

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APPENDIX A

PARTICIPANT INFORMATION FORM

TITLE OF THE STUDY:

Effectiveness of a selected training program in improving the agility & vertical jump performance in hurdlers players.

PURPOSE OF THE STUDY:

I would like to enroll you to take part in my study where I look forward to find out an effective training program to improve the vertical jump & agility in adolescent hurdlers players. I carry out this study in order to provide an integrative training program aimed at performance enhancement rather than focusing on injury prevention of which a player is concerned more.

STUDY PROCEDURE:

Duration of training will be for six weeks, twice weekly. First day you will be evaluated for vertical jump height & agility. From the next day onwards training will be given for six weeks, two sessions per week. At the end of the sixth week, you will be again evaluated for vertical jump & agility.

BENEFITS OF PARTICIPATING IN THIS TRAINING PROGRAM:

This training may help you to improve your reaction time & also increases your vertical jump .It also helps other players in the future to get benefitted from the outcome of this study.

POSSIBLE RISKS & DISCOMFORTS:

There are possible risks of muscular pain & discomfort during this study. however they can be prevented by proper warming up, cool down & regular training methods. Also proper recovery periods will be given in between training sessions.

CONFIDENTIALITY:

The data collected during this study will be used without revealing your identity even if the results of this study is published.

SAFETY & PROTECTION:

This study has been reviewed by the ethical committee of our college (MSAJ COLLEGE OF PHYSIOTHERAPY) & approval to proceed this study has been provided by them. The ethical committee protects the rights &safety of the study participants.

WITHDRAWAL:

You have all the rights to withdraw from this study with prior intimation given to the researcher at anytime during the study.

INFORMED CONSENT FORM

STATEMENT OF THE PARTICIPANT

I, Mr. / Ms _____ have been explained in detail about the procedures to be carried out in the study.

I have been allowed to discuss & ask questions with the concerned physiotherapist regarding this study to clarify my doubts & have understood that there will be no harm in participating in this study.

I agree for notifying my coach regarding the study & I do agree voluntarily to participate in this study. I assure that I will not undergo any other training during the six weeks of this study.

Name of the participant Signature of the participant Date

Name of the investigator Signature of the investigator Date

APPENDIX B

EVALUATION FORM

Date:……

Name :

Age : yrs.

Gender :

Height : Cms. Weight : Kg.

Address :

Phone :

E-mail :

Dominance :

Level/Team :

Position :

Grade :

Experience :

Group : A/B

Screening questions:

1. Currently participating in competition Yes/No

2. Currently under any specific training Yes/No, if yes, specify

3. Recent fractures to the lower limb Yes/No, if yes, specify

4. Presence of Back pain Yes/No

DATA EVALUATION FORM

Measurements: 1. Vertical jump height measured in centimeters at 1st day & at the end of 6th week.

2. Agility T-test measured in seconds at 1st day & at the end of 6th week.

VERTICAL JUMP TEST

Trials	**Vertical jump (Centimeters)**	
	Pre-test Value	**Post-test value**
1		
2		
3		
Average		

AGILITY T-TEST

S.No.	**Agility T-test(seconds)**	
	Pre-test	**Post-test**

APPENDIX C

MASTER CHART - 1

		VERTICAL JUMP TEST		DIFF	AGILITY T-TEST		DIFF
	Samples	pre-test	post-test		pre-test	post-test	
GROUP-A	1	39	44	5	12	11.2	0.8
	2	38	45	7	12	11	1
	3	39	45	6	13	12.5	0.5
	4	37	41	4	12.8	12	0.8
	5	40	44	4	12.9	12.2	0.7
	6	41	46	5	13	12.3	0.7
	7	37	43	6	13.5	12.7	0.8
	8	41	44	3	14	13	1
	9	40	44	4	13.8	13	0.8
	10	38	42	4	12.5	11.8	0.7
	11	39	44	5	12	11.2	0.8
	12	40	44	4	12.5	11.7	0.8
	13	42	47	5	12.6	11.3	1.3
	14	44	48	4	13.5	12.3	1.2
	15	40	44	4	14.2	13	1.2

APPENDIX D

MASTER CHART - 2

		VERTICAL JUMP TEST		DIFF	AGILITY T-TEST		DIFF
	Samples	pre-test	post-test		pre-test	post-test	
GROUP-B	1	40	44	4	13.7	13.6	0.1
	2	42	45	3	13.2	13	0.2
	3	39	43	4	13	13	0
	4	37	41	4	12	11.8	0.2
	5	41	44	3	13	13	0
	6	43	46	3	12.2	12	0.2
	7	38	43	5	12.3	12.1	0.2
	8	41	43	2	12.5	12.5	0
	9	44	46	2	12.8	12.8	0
	10	38	41	3	12.6	12.3	0.3
	11	40	44	4	13	13	0
	12	39	43	4	14.1	13.8	0.3
	13	44	46	2	13.8	13.4	0.4
	14	41	43	2	12.9	12.6	0.3
	15	38	42	4	12.6	12.6	0