EFFECTIVENESS OF PLYOMETRIC TRAINING VERSUS LADDER TRAINING ALONG WITH MANUAL THERAPY ON POWER AND AGILITY AMONG GYMNASTIC SUBJECTS WITH POST ACHILLES TENDON RUPTURE-A COMPARATIVE STUDY

Nancy Elizabeth David sigamani[1] Rajesh Kannan Karuppaiyan[2] Dr. D. Basil Jebaslin Durai[3], MPT., Ph.D., Dr S PURNA CHANDRA SHEKHAR[4] Dr Sivakumar Chinnusamy[5] Dr.Pradeepa mani[6]

MPT (sports), PPG College of Physiotherapy
Affiliated to The Tamil Nadu Dr MGR Medical University, Chennai, India

Ph D Scholar ,Saveetha College of Physiotherapy,
Saveetha institute of Medical and Technical Sciences, Thandalam, Chennai, India
ORC ID: 0009-0001-4996-5415

Principal / Professor
Christian College of Physiotherapy, Kanyakumari
Affiliated to The Tamil Nadu Dr MGR Medical University, Chennai, India

Principal & Head of the Institute
PDS Institute of Physiotherapy, KNR UNIVERSITY OF HEALTH SCIENCES
Telangana, India.

Corresponding Author:Dr Sivakumar Chinnusamy[5], PhD in Physiotherapy
Principal, Department of Physiotherapy,
PPG College of Physiotherapy, Coimbatore
Affiliated to The Tamil Nadu Dr MGR Medical University Tamil Nadu, India.
ORC ID: https://orcid.org/0000-0003-0047-1913

PhD in physiotherapy,Principal
SNS college of Physiotherapy, Coimbatore
Affiliated to The Tamil Nadu Dr MGR Medical university Chennai, Tamil Nadu.

Nancy Elizabeth David sigamani[1] Rajesh Kannan Karuppaiyan[2] Dr. D. Basil Jebaslin Durai[3], MPT., Ph.D., Dr S PURNA CHANDRA SHEKHAR[4] Dr Sivakumar Chinnusamy[5] Dr.Pradeepa mani[6]

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ABSTRACT:

BACKGROUND: Achilles tendon rupture is a prevalent injury in gymnastics, often resulting from high-impact movements such as sudden jumping, fast-twitch activities, abrupt directional changes, dorsiflexion of the foot, or missteps from significant heights

OBJECTIVE: This study aimed to assess the effects of plyometric training, ladder training, and manual therapy on power and agility in female gymnasts recovering from partially ruptured Achilles tendons.

SUBJECTS AND METHODS:A total of 20 female gymnasts aged 18–25 years with partial Achilles tendon ruptures were selected and divided into two groups using a convenient sampling technique. Group A (n=10) underwent plyometric training combined with manual therapy, while Group B (n=10) received ladder training combined with manual therapy. Both groups participated in 60-minute training sessions over an 8-week period.The objective and the aim was clearly explained to the ethical committee. The primary outcome measures included power, assessed using the Sargent Jump Test (SJT)**,** and agility, evaluated using the Agility T-Test**.**The statistical analysis was performed using paired and unpaired t-tests. The paired t-test revealed a significant improvement in post-test values compared to pre-test values within both groups, indicating that both training methods contributed to enhanced power and agility. Furthermore, the unpaired t-test was used to compare post-test results between Group A and Group B.

RESULTS:The statistical findings showed that while both groups experienced significant improvements, Group B (ladder training and manual therapy) demonstrated a greater enhancement in agility and power compared to Group A (plyometric training and manual therapy)**.** The results align with existing literature emphasizing the benefits of ladder training in improving neuromuscular coordination, speed, and agility by reinforcing quick foot movements and cognitive processing. Similarly, plyometric training was effective in developing explosive power by utilizing the stretch-shortening cycle (SSC) to enhance muscle fiber tension and force production. Manual therapy was found to be a crucial component of rehabilitation, aiding in joint mobilization, strength recovery, and range of motion enhancement.

CONCLUSION: This study provides valuable insights into rehabilitation strategies for athletes recovering from Achilles tendon injuries. It underscores the importance of incorporating agility ladder drills and manual therapy as effective interventions to restore athletic performance. Future research should explore long-term outcomes and the potential integration of these methods into broader sports rehabilitation protocols.
KEYWORDS: Gymnastics injuries, Plyometric training, Sargent Jump Test (SJT), Agility T-Test, Stretch-shortening cycle (SSC)

1.INTRODUCTION

Gymnastics is a dynamic and physically demanding sport that combines strength, agility, balance, flexibility, and coordination. With increasing global participation and media attention, gymnastics has evolved into a highly competitive discipline, but it also presents a significant risk of injuries. Among these, Achilles tendon injuries, including partial and complete ruptures, are particularly prevalent, especially in female collegiate gymnasts. These injuries can have severe implications, ranging from pain and functional limitations to prolonged recovery periods and, in some cases, surgical intervention.The high-impact nature of gymnastics—characterized by explosive jumps, rapid changes in direction, and repetitive landings—places tremendous stress on the musculoskeletal system, particularly the Achilles tendon. Studies have shown that forces exerted on the lower limbs during gymnastics can reach up to 15 times an athlete's body weight, significantly increasing the likelihood of tendon overuse and rupture. The injury risk is further heightened by factors such as improper

technique, inadequate conditioning, prolonged training durations, and insufficient recovery periods.Achilles tendon ruptures (ATRs) are typically caused by sudden, excessive tensile loading of the tendon, often occurring during activities like tumbling, vaulting, or dismounting from apparatus. Biomechanical and structural factors also contribute to the injury, including reduced blood supply, tendon fiber degeneration, and repetitive microtrauma. Moreover, gymnasts specializing in multiple events or training from an early age are more susceptible to chronic tendon injuries due to sustained exposure to high-intensity movements.The classification of Achilles tendon injuries, such as the Kuwada and Smigielski systems, helps in diagnosing the severity of partial or complete ruptures and determining the most effective treatment strategies. Clinical assessments, including the Thompson and Matles tests, alongside imaging techniques like ultrasound and MRI, are essential for accurate diagnosis. While conservative management involving immobilization, physiotherapy, and progressive loading exercises is effective for less severe cases, surgical intervention is often required for complete ruptures to restore tendon integrity and function.Rehabilitation and injury prevention strategies play a crucial role in returning gymnasts to peak performance. Plyometric training, ladder drills, and manual therapy techniques such as myofascial release help improve lower limb strength, coordination, and proprioception. Additionally, agility-based exercises and neuromuscular training contribute to enhanced tendon resilience,reducing the risk of reinjury. Given the high recurrence rate of Achilles tendon injuries, implementing structured conditioning programs and biomechanical assessments is essential for long-term athletic sustainability.This study aims to provide an in-depth analysis of Achilles tendon injuries in gymnasts, examining the epidemiology, biomechanics, classification, clinical diagnosis, treatment options, and rehabilitation interventions. By understanding the underlying mechanisms and risk factors, sports scientists, physiotherapists, and coaches can develop evidence-based strategies to optimize performance while minimizing injury risks in elite gymnasts.

2. NEED OF THE STUDY

In the last decade, the incidence of AT rupture has increased largely, most AT rupture occurs during sports and involves Biomechanical and biochemical changes related to aging play a significant role in injury. The highest frequency of Achilles tendon was found in gymnastics; hence it was important to pay closer attention to Achilles tendon among gymnasts. Women who compete in collegiate gymnastics have a higher incidence of Achilles tendon ruptures than the overall population.Plyometric training and Ladder training are known to help in improving the efficiency of lower limb muscular endurance but there are no adequate studies to show which is effective and which training is the best for post-Achilles tendon rupture in gymnastics subjects.Hence the need of the study is to find out the effectiveness of Plyometrics and ladder training along with manual therapy on agility and power among gymnastics subjects Post Achilles tendon rupture.

3. METHODOLOGY

STUDY DESIGN: The study was designed as a comparative research study with a pre- and post-test evaluation to assess the effects of different training interventions on power and agility in female gymnasts recovering from Achilles tendon rupture.

SUBJECTS: A total of 20 subjects, selected through a simple random sampling technique, were divided into two groups: Group A, which received plyometric training and manual therapy, and Group B, which underwent ladder training along with manual therapy. The study was conducted over six months at PPG Sports Academy, Coimbatore. Participants met strict inclusion criteria, including female gymnasts aged 18 to 25 years with a confirmed post-Achilles tendon rupture, positive Thompson and Matles test results, and specific agility and jump performance benchmarks. Exclusion criteria included superior agility and jump scores, psychological disorders, flat feet, or arthritic changes. Power and agility, the study's dependent variables, were assessed using the Sargent jump test and the Agility T-test, respectively, while plyometrics, ladder training, and manual therapy served as independent variables. Essential materials for the study included a couch, paper, pen, ladder, chalk, and a stopwatch for accurate performance measurement. The need and objectives of the study were clearly explained to the ethical committee of PPG COLLEGE OF PHYSIOTHERAPY and permission was obtained. After obtaining permission the study was conducted at the sports academy of PPG SPORTS ACADEMY. Before the treatment, the procedure was clearly explained to the subjects. Each subject was asked to read and sign the consent form.20 subjects were selected for the study based on selection criteria. The subjects were divided into Group A and Group B with 10 subjects in each group. The special test for Achilles tendon rupture Thompson test was performed to identify the injury. The treatment technique involves Plyometric training along with Manual therapy for Group A and Ladder training along with Manual therapy for Group B. The Pre and Post-test values of power and agility using the Sargent Jump test and Agility T-test data were recorded and analyzed.The subjects in Group A were receiving Plyometric training along with Manual mobilization and Group B were receiving Ladder training along with Manual mobilization. Before the treatment session, a basic warm-up routine was performed by the subjects. The Pre and Post-test values of power and agility using, the Sargent Jump test and Agility T test were recorded and analyzed.The treatment session was conducted for 3 days a week for 8 weeks. Each session of both groups comprised of 60 minutes. That 60 minutes of Plyometric training with a rest period of 2 minutes in between each set for Group A along with manual therapy session for 7 minutes on the next day of training, and 60 minutes of Ladder

training with a rest period of 2 minutes between each set for Group B along with manual therapy session for 7 minutes on the next day of training were given. Subjects of each group were given soft tissue mobilization for gastrocnemius and soleus muscle every alternative day of the exercise intervention.

DESCRIPTION OF EXPERIMENTAL INTERVENTION

GROUP A: PLYOMETRIC TRAINING WITH MANUAL MOBILIZATION

WEEKS	TRAINING	ETS AND REPS	REST (MIN)
Week 1 -2	Lateral hop Squat lunge Step up. Rim Jump	1 × 10	2
	Lateral hop Squat lunge Step up. Rim jump	2 × 10	2
	Squat jump	1× 10	2

Week 3-4	23 m bounding 23 m skipping	1 × 1	2
Week 5-7	Lateral hop Squat lunge Step up. Rim jump	3× 10	2
	Squat jump	2 × 10	2
	23 m bounding 23 m skipping	2 × 1	2
Week 8	Lateral hop Squat lunge Step up. Rim jump	3× 10	2
	23 m bounding 23 m skipping	3 × 1	2

GROUP B: LADDER TRAINING WITH MANUAL MOBILIZATION

Table 2: LADDER TRAINING FOR GROUP B

WEEKS	**TRAINING**	**OMPLEXITY, SETS, INTENSITY AND REST PERIOD**

WEEK 1 - 3	Two-footrun Bunny hops Slalom jumps. Bunny twist Lateral run	Complexity-Easy Sets - 3 Intensity -Fast Rest -2 mins
WEEK 4-6	Side reach run Bunny twist Brake run. Lateral run Two in, two out lateral run In and out bunny hops	Complexity-Moderate Sets - 3 Intensity -Fast Rest -2 min
WEEK 7 - 8	Sidestep run (Icky shuffle) Crazy bunny Out, out in with hiprotation Brake run. Carioca step	Complexity-Hard Sets - 3 Intensity -Fast Rest -2 min

MANUAL THERAPY FOR BOTH GROUP A AND GROUP B

The primary purpose was to mobilize soft tissue. The soft tissue mobilization includes the mobilization of gastrocnemius /soleus muscle to address joint mobility restriction. The active release techniques of the gastrocnemius and soleus muscle

PALPATORY PROCEDURE

The gastrocnemius and soleus muscles are palpated with the thumb of the therapist by applying a small amount of pressure to them.

METHOD

With mild pressure applied to the muscle, an active movement of the ankle is done by the patient by dorsiflexing and plantar flexing the ankle while the therapist moves her thumb in the direction of the palpated muscle.

TREATMENT PROTOCOL

The total duration is 3 months, and the treatment session duration will be 8 weeks with a rest period. 3 sessions per week. Total 24 sessions in 8 weeks. The manual therapy session will commence on the next day of the exercise training for a total of 7 minutes for each subject of Group A and 7 minutes for each subject of Group B. Manual therapy subjects were advised to apply an ice pack at home along with a home program.

Muscles Involved In Trigger Release – calf muscle (Gastrocnemius and soleus)
Patient Position – Prone lying on the treatment table.
Therapist Position – Walk standing position

Cool Down:

The participant was asked to jog at a light tempo for 5 min at the speed he/she felt comfortable with.

STATISTICAL ANALYSIS:

The result was analysed for pre and post test values using paired 't' test favored for alternate hypothesis. The statistical tool used in this study are paired t-test. The paired t-test was used for within group analysis. Pre -test and post-tet values were calculated using paired t test at significant level $p<0.05$ with t-value.

RESULTS

TABLE NO.1 SARGENT JUMP TEST FOR GROUP A AND B

Sargent Jump Test	Mean (Pre-Test)	Mean (Post-Test)	SD (Pre-Test)	SD (Post-Test)	Calculated t-Value	Table t-Value	p-Value	Significance
Group A (Plyometrics + Manual Therapy)	685.1	841.4	38.5	56.6	7.22	2.26	p < 0.05	Significant
Group B (Ladder Training + Manual Therapy)	709.67	889.05	38.5	52.14	8.75	2.26	p < 0.05	Significant

RESULT: The statistical analysis of the Sargent Jump test for power demonstrated significant improvements in both Group A and Group B following their respective training interventions.

For **Group A**, which underwent **Plyometric training along with Manual therapy**, the **Mean and Standard Deviation** of Pre-test and Post-test values were **685.1 ± 38.54** and **841.4 ± 56.63**, respectively. The paired t-value was greater than the table value at **$p < 0.05$**, indicating a statistically significant improvement in power.

For **Group B**, which underwent **Ladder training along with Manual therapy**, the **Mean and Standard Deviation** of Pre-test and Post-test values were **709.67 ± 38.5** and **889.05 ± 52.14**, respectively. Similar to Group A, the paired t-value exceeded the table value at **$p < 0.05$**, confirming a significant increase in power.

TABLE NO.2 AGILITY T-TEST FOR GROUP A AND B

Agility T-Test	Mean (Pre-Test)	Mean (Post-Test)	SD (Pre-Test)	SD (Post-Test)	Calculated t-Value	Table t-Value	p-Value	Significance
Group A (Plyometrics + Manual Therapy)	11.4	10.59	0.23	0.28	7.028	2.26	$p < 0.05$	Significant
Group B (Ladder Training + Manual Therapy)	11.07	10.24	0.40	0.11	6.32	2.26	$p < 0.05$	Significant

RESULT: The statistical analysis of the **Agility T-Test for pain** demonstrated significant improvements in both **Group A** and **Group B** following their respective training interventions.

For **Group A**, which underwent **Plyometric training along with Manual therapy**, the **Mean and Standard Deviation** of Pre-test and Post-test values were **11.4 ± 0.23** and **10.59 ± 0.28**, respectively. The paired t-value was greater than the table value at **$p < 0.05$**, indicating a statistically significant reduction in pain.

For **Group B**, which underwent **Ladder training along with Manual therapy**, the **Mean and Standard Deviation** of Pre-test and Post-test values were **11.07 ± 0.40** and **10.24 ± 0.11**, respectively. Similar to Group A, the paired t-value exceeded the table value at **$p < 0.05$**, confirming a significant improvement in pain levels.

BETWEEN GROUP ANALYSES

BETWEEN-GROUP ANALYSIS OF POWER IN GROUP A AND GROUP B

SARGENT JUMP TEST	GROUP	SAMPLE SIZE	MEAN	SD	CALCULATED t - Value	TABLE t value	P VALUE
PRE TEST	**A**	**10**	**685.19**	**38.54**	**1.42**	**2.101**	**P>0.05 Not Significant**
	B	**10**	**709.67**	**38.54**			

POST TEST	**A**	**10**	**841.4**	**56.63**	**2.786**	**2.101**	**P<0.05 Significant**
	B	**10**	**889.05**	**52.14**			

Table NO.3 Group Analysis of Power between Group A and Group B

RESULT:

The mean and standard deviation values of pretest for Group A and B were 685.19,38.54 and 709.6,38.54 respectively, the result is enlisted in the above. The obtained t value is lesser than the table value at the significant level of p>0.05 with 18 degrees of freedom.

The mean and standard deviation value of post-test for Group A and B were 841.4,56.63 and 889.05,52.14. The obtained t value is greater than the table t val **BETWEEN-GROUP ANALYSIS OF POWER IN GROUP A AND GROUP B**

BETWEEN GROUP ANALYSIS OF AGILITY IN GROUP A AND GROUP B

AGILITY T-TEST	GROUP	SAMPLE SIZE	MEAN	SD	CALCULATED t - Value	TABLE t-Value	P VALUE
PRE-TEST	A	10	11.42	0.23	0.0685	2.26	P>0.05 Not Significant
	B	10	11.43	0.40			
POST-TEST	A	10	10.59	0.28	3.6791	2.26	P<0.05 Significant
	B	10	10.24	0.11			

Table NO. 4 Group Analysis of Agility between Group A and Group B

RESULT:

The mean and standard deviation values of the Pre-test for Groups A and B were 11.42 ,0.23 and 11.43,0.40 respectively, the result is enlisted in the above. The obtained t value is lesser than the table value at the significant level of p>0.05 with 18 degrees of freedom.

The mean and standard deviation values of post-test for Group A and B were 10.59,0.28 and 10.24,0.11. The obtained t value is greater than the table t value at the significant level of p<0.05 with 18 degrees of freedom.

5. DISCUSSION

Gymnastics is a well-known sport with physical fitness to perform a variety of skills which also need power, speed, strength, endurance agility, and flexibility and also in which highest rate of Achilles tendon rupture takes place causing problems with power and agility. Achilles tendon rupture frequently occur in sports like gymnastics which involves sudden jumping, and fast twitching activities. In addition, missteps fall from great heights, direct strikes to the tendon, and

abrupt motions like pushing off or dorsiflexion of the foot can result in ruptures of the Achilles tendon in gymnastics.In the present study, 20 female gymnasts were selected to participate in the study with of age between 18-25 years with partially ruptured Achilles tendons. 6 weeks after the injury, the subjects were given plyometric training, ladder training, and manual therapy.Plyometric training and Manual therapy Group A (n=10). Ladder training and Manual therapy Group B (N=10) by convenient sampling technique for 60 minutes till 8 weeks. The Pre-test value of power was evaluated by the Sargent Jump test and Agility T-test. The statistical tool used for the data analysis is paired t' test and unpaired t-test. the statistical report shows that there was a significant improvement in the post-test values than the pre-test values in both Group A and Group B. Unpaired t-test was used to find out the significance of pre-test and post-test values and the statistical report shows there was no significant difference in the pretest and shows significant difference in the post test. The calculated t value for the above mentioned test were greater than the table t value. Thus, the result shows that Group A and Group B showed significant improvement in both groups. but Group B showed significant improvement compared to Group

..**Mohd Waseem Jan Padder1, and Dr. G. Ramesh2,2019** they conducted a study to find out how ladder training and plyometric training affected school-level Kho-kho players' explosive strength and agility was the primary goal of the research. An age range of 14 to 17 years was observed in 45 male Kho-kho players who had participated in interschool competitions and were players from Higher Secondary Schools Vessu Anantnag, Wanpoh Anantnag, and Kelam Kulgam in Kashmir. The subjects were chosen at random. Three equalxxx groups of fifteen Kho-kho players each experimental group I, experimental group II, and control group—were randomly allocated to the 45 selected subjects. At 0.05, the degree of confidence was set. Finally, they have found that plyometric and ladder training greatly increased explosive power and agility.**Pramod R, Dr. Divya K 2019** they have conducted a study to determine how ladder training affected pupils' speed in Egyptian schools. Thirty boys were chosen at random from Ideal Indian School in Doha, Qatar, to be the subjects of the study. They were between the ages of 13 and 17. There were two groups of the chosen subjects, each containing fifteen (N=15) subjects. Group II acted as the control group while Group I received ladder training. They have concluded that participants in a 6-week ladder training program saw a considerable gain in speed.**DAMIAN MIREL (2014)** conducted a study to find the effects of Manual therapy and Eccentric exercises in the management of Achilles tendinopathy in 3 runners. First subject received AP glide of the talus and subjects 2 and 3 received hypo mobile AP glide of the Talus and Lateral glide at the subtalar joint along with eccentric exercises they conclude that Manual therapy to be a safe and effective intervention in the rehabilitation of chronic tendinopathy**JASON GLIKMAN (2015)** conducted a study to find the Use of Manual Therapy And Strengthening Exercises To Improve Plantarflexion Strength And Mobility Following Achilles Tendon Repair as a Case Report43-year-old male presented to physical therapy following an Achilles tendon rupture and repair. He was seen for 24 visits and underwent a manual therapy program consisting of joint mobilization of the talocrural joint, distal tibiofibular joint, and metatarsophalangeal joint, soft tissue mobilization (STM) to the triceps surae, plantar fascia, and anterior tibialis, and passive ROM of the Ankle The prognosis for this patient is good and is expected to recover well from surgery. The statistical analysis showed that the calculated t' value using the paired 't' test for SJT in Group A and Group B was greater than the table t value of with. The statistical analysis between the groups using the unpaired 't' test for SJT showed the calculated t value of post - post comparison greater.The statistical analysis showed that the calculated 't' value using the paired 't' test for agility in Group A and

Group B was greater than the table t value.The statistical analysis between groups using unpaired 't' test for Agility T test showed the calculated 't' value of post- post comparison greater.

6. LIMITATIONS:

The sample size of the study was smaller.

Follow-up effects of treatment technique were not done.

Participants selected for the study were only female players

This study was limited to particular age group due to the non-availability of resources**.**

7.SUGGESTIONS:

1.Sample size can be increased by including more subjects to generalize the effect in a large population.

2.The period of study should be increased as the disease process is also long; hence it may lead to better and valuable results.

3.Further studies can be done with different age groups.

4.Further studies can be done based on different outcomes.

8.CONCLUSION

This study concluded that both groups showed that there was a significant improvement in Power and Agility after the application of the treatment. However, Group B (Ladder training and manual therapy) showed significant improvement over Group A (Plyometric training and Manual therapy) in Power and Agility

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