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Research Article

Effect Of Plyometric Exercises Versus Mulligan Mobilization With Movement On Pain, Function And Grip Strength In Racket Sports Players With Chronic Lateral Epicondylitis: A Comparative Study

Dr. Shreya Sandeep Gulve[1], Dr. M. Vijayakumar[2]

[1] Department of Physiotherapy (Musculoskeletal Physiotherapy), PES Modern College of Physiotherapy, Pune, Maharashtra, India.
Email: shreyagulve1002@gmail.com

[2] Department of Physiotherapy (Musculoskeletal Physiotherapy), PES Modern College of Physiotherapy, Pune, Maharashtra, India.
Email: atlasvijayakumar@gmail.com

ABSTRACT:

Background: Chronic lateral epicondylitis is associated with lateral elbow pain, functional limitation, and reduced grip strength and may interfere with participation in racket sports. Plyometric exercise and Mulligan Mobilization with Movement (MMWM) address rehabilitation through different mechanisms, but comparative evidence in recreational racket-sports players is limited.

Objective: To compare the effects of Plyometric Exercises and MMWM on pain, functional disability, and grip strength in recreational racket sports players with chronic lateral epicondylitis after four weeks of treatment.

Methods: A quasi-experimental study included 62 eligible participants, of whom 60 completed the intervention and were included in the final analysis, with 30 participants in each group. Group A received progressive upper-limb Plyometric Exercises with conventional physiotherapy, while Group B received MMWM with conventional physiotherapy. Treatment was provided for four weeks, three sessions per week, for 12 sessions. Pain, function, and grip strength were assessed using the Numerical Pain Rating Scale (NPRS), Patient-Rated Tennis Elbow Evaluation (PRTEE), and Hand-held Dynamometer, respectively. Assessments were performed at baseline and weekly through Week 4. Data were analysed using SPSS version 26.0 with Repeated Measures ANOVA and Independent Samples t-test.

Results: Both groups demonstrated significant within-group improvement in all outcomes ($p < 0.001$). At Week 4, NPRS was 1.30 ± 0.84 in Group A and 0.37 ± 0.56 in Group B ($p < 0.001$). PRTEE was 24.73 ± 1.86 in Group A and 38.03 ± 3.31 in Group B ($p < 0.001$). Grip strength was 40.10 ± 6.27 kg in Group A and 34.90 ± 6.84 kg in Group B ($p = 0.003$).

Conclusion: Both interventions were effective. MMWM demonstrated greater improvement in pain, whereas Plyometric Exercises demonstrated greater improvement in functional ability and grip strength. The findings suggest that treatment selection may be guided by the principal rehabilitation goal.

Keywords: Chronic lateral epicondylitis; tennis elbow; plyometric exercise; Mulligan mobilization

with movement; pain; function; grip strength; racket sports.

INTRODUCTION

Lateral epicondylitis is a common musculoskeletal condition characterized by pain and tenderness over the lateral aspect of the elbow. Repetitive gripping, wrist extension, and forearm movements can place repeated mechanical stress on the common extensor tendon, with the extensor carpi radialis brevis being frequently implicated. The condition can result in pain, reduced grip strength, and difficulty with functional and sporting activities.[1,3]

Racket sports players are particularly exposed to repetitive upper-limb loading. Badminton, tennis, paddle tennis, and squash involve repeated gripping, wrist extension, forearm rotation, and rapid movements. Reported elbow injury proportions vary across racket sports, while lateral epicondylitis remains a relevant problem in recreational players.[1,2]

Pain and reduced functional capacity may interfere with gripping, lifting, carrying objects, computer use, household activities, racket handling, and stroke execution. Assessment of pain, functional disability, and grip strength therefore provides a clinically relevant multidimensional evaluation of treatment response.[13,7,8,22]

Exercise-based rehabilitation is an important component of management. Plyometric exercises use rapid eccentric-to-concentric muscle actions and the stretch-shortening cycle and can be progressed to improve neuromuscular coordination, force production, muscular capacity, and tolerance to repeated upper-limb loading.[16,12]

Mulligan Mobilization with Movement involves a sustained lateral glide combined with active, pain-free movement. The technique is intended to facilitate pain-free movement and may reduce pain while improving functional use and grip strength.[3,4,5,6]

Previous studies have reported beneficial effects of both exercise-based and manual therapy approaches in lateral epicondylitis, but limited evidence directly compares progressive upper-limb Plyometric Exercises with MMWM in recreational racket sports players. The present study was therefore undertaken to compare their effects on pain, functional disability, and grip strength over four weeks.

MATERIALS AND METHODS

Study design and setting

A quasi-experimental study was conducted in a physiotherapy outpatient department and racket sports academies in and around the city. The study duration was 18 months and the intervention duration was four weeks (12 sessions; three sessions per week).

Participants and sample size

The sample size was calculated using OpenEpi software based on a prevalence of 14.1%, 95% confidence level, 10% margin of error, and a population size of 100. The estimated sample size was 28 per group using the maximum reported prevalence from a previous study. With an expected dropout rate of 10%, 62 participants were recruited. Participants were conveniently assigned in a 1:1 ratio to the two intervention groups using the envelope method. Sixty participants completed the study and were included in the final analysis, with 30 participants per group.

Eligibility criteria

Participants were aged 20–40 years, were recreational racket sports players with at least six months of playing experience, had lateral elbow pain of 4–6 weeks duration, had a positive Cozen's test, and had an NPRS score between 4 and 7. Participants were excluded for previous trauma, fracture, dislocation or bony abnormality around the elbow; previous elbow surgery; current physiotherapy; neurological impairment; or systemic illness including metabolic, metastatic, or infective disorders. Participants could withdraw at any time and were excluded from final analysis if they missed ≥3 consecutive sessions or >4 of 12 total sessions.

Ethics and registration

Ethical approval was obtained from the Institutional Ethics Committee before commencement of the study. The study was prospectively registered with the Clinical Trials Registry–India before participant recruitment (CTRI/2026/02/102857). Written informed consent was obtained from all participants. Confidentiality was maintained and participants were informed of their right to withdraw without affecting their participation or treatment.

Outcome measures

Pain intensity was assessed using the Numerical Pain Rating Scale (NPRS), an 11-point scale from 0 to 10. Functional disability was assessed using the Patient-Rated Tennis Elbow Evaluation (PRTEE), with a total score ranging from 0 to 100, where lower scores indicate less pain and disability. Grip strength was measured in kilograms using a Hand-held Dynamometer. These measures were recorded at baseline and at the end of Weeks 1, 2, 3, and 4.[7,8,22]

Intervention protocol

Group A received progressive Plyometric Exercises along with conventional physiotherapy. The programme included dribbling a weighted ball against the wall/floor, flipping and catching a weighted ball, bouncing a tennis ball on a racket, rapid eccentric/concentric elbow and forearm

motions against elastic resistance, and rapid chest or overhead passes using a weighted plyometric ball. Exercise intensity and repetitions were progressed across four weeks as specified in Table 1.

Exercise	Week 1	Week 2	Week 3	Week 4
Dribbling weighted ball against wall/floor	0.5–1 kg; 3×20 s	1–2 kg; 3×30 s	2–3 kg; 3×40 s	3 kg; 3×50 s
Flipping & catching weighted ball	0.5 kg; 3×10 reps	1 kg; 3×15 reps	1.5–2 kg; 3×20 reps	Partner/wall rebound; 3×30 reps
Bouncing tennis ball on racket	Short-handled; 3×20	Long-handled; 3×30	Long-handled; 3×40	Long-handled; 3×60
Rapid eccentric/concentric elbow & forearm motion	Yellow band; 3×10	Red band; 3×15	Green band; 3×20	Blue band; 3×30
Rapid chest/overhead passes with weighted ball	1 kg; 3×10	1–2 kg; 3×15	2–3 kg; 3×20	Overhead/one-handed/partner drills; 3×30

Table 1. Group A progressive plyometric exercise protocol

Group B received Mulligan Mobilization with Movement along with conventional physiotherapy. The participant was positioned supine with the elbow extended, forearm pronated, and wrist neutral. A lateral glide was applied to the proximal forearm with the appropriate glide to the distal humerus while the participant performed a pain-free gripping action. The glide was sustained for 5–10 seconds, with no longer than 60 seconds between repetitions. Three sets of 10 repetitions were performed. Treatment was delivered three times per week for four weeks.

Conventional physiotherapy consisted of pulsed ultrasonic therapy applied at the tenoperiosteal junction of the extensor carpi radialis brevis. The pulse ratio was 1:4, frequency 1 MHz, and intensity 1.5 W/cm², provided three sessions per week for four weeks (12 sessions).

Statistical analysis

Data were analysed using Statistical Package for the Social Sciences (SPSS) version 26.0. Continuous variables were expressed as mean ± standard deviation and categorical variables as frequency and percentage. The Shapiro–Wilk test demonstrated normal distribution for NPRS ($W = 0.957$, $p = 0.072$), PRTEE ($W = 0.964$, $p = 0.089$), and grip strength ($W = 0.952$, $p = 0.061$). Repeated Measures ANOVA was used to evaluate changes across the five assessment time points within each group. Independent Samples t-test was used for between-group comparisons at baseline and at the end of the intervention. A p-value <0.05 was considered statistically significant.

RESULTS

Participant characteristics

A total of 60 participants completed the study, with 30 in each group. The mean age was 27.00 ± 3.82 years in Group A and 27.83 ± 4.03 years in Group B. Group A comprised 19 males (63.3%) and 11 females (36.7%), whereas Group B comprised 16 males (53.3%) and 14 females (46.7%). Right-sided involvement was present in 21 participants (70.0%) in Group A and 22 participants (73.3%) in Group B.

Baseline inter group comparison

There were no statistically significant baseline differences between the groups for NPRS ($p = 0.632$), PRTEE ($p = 0.216$), or grip strength ($p = 0.532$), indicating comparability before intervention.

Parameter	Group A Mean ± SD	Group B Mean ± SD	p value
NPRS	6.20 ± 0.81	6.10 ± 0.80	0.632
PRTEE	57.17 ± 2.72	58.03 ± 2.65	0.216
Grip strength (kg)	28.57 ± 5.91	27.60 ± 5.99	0.532

Table 2. Baseline inter-group comparison

Intra-group changes

In **Group A**, NPRS decreased progressively from 6.20 ± 0.81 at baseline to 5.23 ± 0.73 at Week 1, 4.07 ± 0.83 at Week 2, 2.77 ± 0.86 at Week 3, and 1.30 ± 0.84 at Week 4. Repeated Measures ANOVA demonstrated a statistically significant change over time ($p < 0.001$). PRTEE decreased from 57.17 ± 2.72 at baseline to 51.97 ± 2.46, 44.30 ± 2.05, 35.37 ± 2.04, and 24.73 ± 1.86 at Weeks 1–4, respectively ($p < 0.001$). Grip strength increased from 28.57 ± 5.91 kg at baseline to 30.43 ± 5.76, 33.17 ± 5.79, 36.53 ± 6.20, and 40.10 ± 6.27 kg at Weeks 1–4, respectively ($p < 0.001$).

In **Group B**, NPRS decreased from 6.10 ± 0.80 at baseline to 3.93 ± 0.98, 2.57 ± 1.07, 1.17 ± 0.87, and 0.37 ± 0.56 at Weeks 1–4, respectively ($p < 0.001$). PRTEE decreased from 58.03 ± 2.65 at baseline to 54.37 ± 2.39, 49.40 ± 2.37, 44.40 ± 2.49, and 38.03 ± 3.31 at Weeks 1–4, respectively ($p < 0.001$). Grip strength increased from 27.60 ± 5.99 kg at baseline to 28.77 ± 6.05, 30.30 ± 6.51, 32.40 ± 6.71, and 34.90 ± 6.84 kg at Weeks 1–4, respectively ($p < 0.001$).

Outcome / Group	Baseline	Week 1	Week 2	Week 3	Week 4	Within-group p
NPRS – Group A	6.20 ± 0.81	5.23 ± 0.73	4.07 ± 0.83	2.77 ± 0.86	1.30 ± 0.84	<0.001
NPRS – Group B	6.10 ± 0.80	3.93 ± 0.98	2.57 ± 1.07	1.17 ± 0.87	0.37 ± 0.56	<0.001
PRTEE – Group A	57.17 ± 2.72	51.97 ± 2.46	44.30 ± 2.05	35.37 ± 2.04	24.73 ± 1.86	<0.001
PRTEE – Group B	58.03 ± 2.65	54.37 ± 2.39	49.40 ± 2.37	44.40 ± 2.49	38.03 ± 3.31	<0.001
Grip strength – Group A (kg)	28.57 ± 5.91	30.43 ± 5.76	33.17 ± 5.79	36.53 ± 6.20	40.10 ± 6.27	<0.001
Grip strength – Group B (kg)	27.60 ± 5.99	28.77 ± 6.05	30.30 ± 6.51	32.40 ± 6.71	34.90 ± 6.84	<0.001

Table 3. Weekly outcome values

Inter-group comparison at Week 4

Outcome	Group A	Group B	Between-group p value	Interpretation
NPRS	1.30 ± 0.84	0.37 ± 0.56	<0.001	MMWM greater pain reduction
PRTEE	24.73 ± 1.86	38.03 ± 3.31	<0.001	Plyometric greater functional improvement
Grip strength (kg)	40.10 ± 6.27	34.90 ± 6.84	0.003	Plyometric greater grip-strength improvement

Table 4. Week 4 Inter-group comparison of outcomes

The Week 4 Inter -group comparison demonstrated statistically significant differences in all three outcomes. The MMWM group had a lower NPRS score, indicating greater pain reduction. The Plyometric Exercise group had a lower PRTEE score, indicating greater improvement in function and higher grip strength, indicating greater improvement in muscular performance.

DISCUSSION

The present study compared progressive Plyometric Exercises and Mulligan Mobilization with Movement, each combined with conventional physiotherapy, in recreational racket sports players with chronic lateral epicondylitis. Both groups demonstrated statistically significant improvements in pain, functional disability, and grip strength over four weeks. However, the pattern of between-group differences was outcome-specific: MMWM produced greater pain reduction, whereas Plyometric Exercises produced greater improvement in function and grip strength.

Changes in Pain

Both interventions significantly reduced NPRS scores over the treatment period ($p < 0.001$). The Week 4 NPRS was lower in the MMWM group (0.37 ± 0.56) than in the Plyometric Exercise group (1.30 ± 0.84), with a statistically significant between-group difference ($p < 0.001$). The greater reduction in pain observed with MMWM may be related to the technique's emphasis on pain-free movement combined with a sustained lateral glide. Such an approach may produce a relatively rapid hypoalgesic response and facilitate movement with less discomfort.[4,5,6]

The progressive Plyometric Exercise programme requires repeated eccentric and concentric muscle-tendon loading. Adaptation to the loading demands may occur progressively as neuromuscular coordination, force production, and tolerance to tendon loading improve. This may explain why the reduction in pain in the Plyometric group was progressive across the four-week period. Previous literature has also reported beneficial effects of exercise-based rehabilitation in lateral epicondylitis.[9,10]

Changes in Function

PRTEE scores improved significantly in both groups. At Week 4, Group A had a lower PRTEE score (24.73 ± 1.86) than Group B (38.03 ± 3.31), with $p < 0.001$. Because lower PRTEE scores represent lower pain and functional disability, this finding indicates greater functional improvement following Plyometric Exercises.

A possible explanation is that progressive plyometric loading directly challenges the upper-limb musculature through rapid eccentric-concentric actions, weighted ball activities, racket-based drills, and resistance-band movements. These exercises may promote neuromuscular coordination, muscular endurance, and tolerance to repeated gripping and wrist movements. This is particularly relevant to racket sports, where rapid force generation and repeated upper-limb movements are required.[16,9]

The present result is consistent with evidence that progressive exercise can improve functional outcomes in lateral epicondylitis. Studies comparing MMWM with strengthening or exercise-based approaches have also reported beneficial effects from both approaches, while differences between

interventions may depend on the outcome being considered.[11,12,5]

Changes in Grip strength

Grip strength increased significantly in both groups ($p < 0.001$). At Week 4, Group A reached 40.10 ± 6.27 kg compared with 34.90 ± 6.84 kg in Group B, with a statistically significant between-group difference ($p = 0.003$). The greater improvement in the Plyometric Exercise group may reflect the repeated and progressive muscular loading incorporated into the intervention.

Pain reduction can permit greater voluntary grip force by reducing pain-related inhibition. However, the progressive resistance and repeated eccentric-concentric loading in the Plyometric Exercise programme may provide an additional stimulus for muscular adaptation. The progression from lighter to heavier medicine balls and resistance bands was designed to increase loading demands across the intervention and may have contributed to the greater final grip-strength value.

Clinical interpretation

The findings suggest that both interventions are useful but may serve different rehabilitation priorities. MMWM may be particularly useful when rapid pain reduction and pain-free movement are the primary concerns. Progressive Plyometric Exercises may be particularly useful when the rehabilitation goal emphasizes functional recovery and restoration of grip strength in recreational racket sports players. The interventions should therefore not be considered mutually exclusive in clinical practice; rather, the present findings identify outcome-specific strengths within the four-week protocol studied.

Strengths and limitations

Strengths included the standardized four-week intervention, use of NPRS, PRTEE, and Hand-held Dynamometer outcomes, and repeated outcome assessment at baseline and at the end of each treatment week. A limitation was that sports performance and return-to-sport outcomes were not assessed; therefore, the effect of the interventions on actual racket-sports performance could not be determined.

CONCLUSION

Both Plyometric Exercises and Mulligan Mobilization with Movement, when combined with conventional physiotherapy, were effective in managing chronic lateral epicondylitis in recreational racket sports players over four weeks. Both interventions significantly reduced pain, improved functional ability, and increased grip strength. When compared directly, MMWM produced greater improvement in pain, whereas Plyometric Exercises produced greater improvement in functional ability and grip strength. Thus, both treatment approaches are beneficial, but their effectiveness differs according to the outcome considered. MMWM may be more useful when pain reduction is the primary concern, whereas Plyometric Exercises may be more beneficial when restoration of function and grip strength is emphasized.

ETHICAL APPROVAL

Ethical approval was obtained from the Institutional Ethics Committee before commencement of the study. The study was prospectively registered with the Clinical Trials Registry–India (CTRI/2026/02/102857).

INFORMED CONSENT

Written informed consent was obtained from all participants before enrolment.

CONFLICT OF INTEREST

There was no conflict of interest.

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