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ORIGINAL ARTICLE

ULTRASOUND THERAPY COMBINED WITH WRIST FLEXIBILITY TRAINING FOR WRIST TENDONITIS IN CLUB LEVEL BADMINTON PLAYERS: A STUDY ON PAIN AND FUNCTION

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ABSTRACT

Background of the study: Badminton is a widely played racket sport characterized by dynamic activity that puts a lot of strain on the upper extremities especially in the wrist joint. Wrist tendonitis is a prevalent overuse injury among badminton players due to repetitive wrist movements involved in the game. Objective of the study is to determine the combined effect of ultrasound therapy and wrist flexibility training on wrist tendonitis among club level badminton players. **Method:** A pre-post experimental study was conducted among 60 club-level badminton players aged 18–25 years, diagnosed with wrist tendonitis and reporting NPRS scores between 3-7. Participants underwent a 4-week intervention program consisting of 7 minutes of ultrasound therapy followed by 30 minutes of wrist flexibility training. Pain and functional outcomes were assessed pre and post- intervention using the Patient-Rated Wrist Evaluation score. Statistical analysis was performed applying the Wilcoxon signed-rank test for pre and post intervention. **Result:** The study found that there was a statistically significant reduction in wrist pain and functional limitation following the intervention. The Wilcoxon signed-rank test showed a significant change ($p < 0.001$), indicating the effectiveness of ultrasound therapy combined with wrist flexibility training in managing wrist tendonitis among club-level badminton players. **Conclusion:** The intervention was effective conservative approach for reducing pain and improving functional outcomes in players with wrist tendonitis. Therefore, the study concludes with the acceptance of Alternate hypothesis which states that there is a significant effect of Ultrasound therapy and wrist flexibility training on wrist tendonitis among Club-level Badminton players.

Keywords: Wrist tendonitis, badminton injuries, ultrasound therapy, wrist flexibility training, PRWE, overuse injuries

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INTRODUCTION

In India, badminton is a well-liked sport that has tremendous player demand. It is a racket sport that requires swift changes of direction and rapid movements of the arms in a variety of reluctant body positions[1]. Both male and female badminton players have seen enormous growth in popularity throughout the years. It is believed that the future of this sport in India would be quite bright, with a growing proportion of female and male Badminton players representing India in this sport[2]. Although it's one of the most popular sports in the world, sports medicine hasn't got much attention from it. Over the previous few decades, lower effective playing time and increasing shot frequency in Olympic-level badminton matches indicate that the game has gotten faster[3].

The essential physical qualities required for a badminton player to excel in the sport are aerobic power, agility, strength, explosive power, speed, flexibility, balance, and coordination. According to the movement, an athlete must have agility and endurance in order to follow the shuttlecock and return to the middle after a hit to get ready to return point. Strong limb power will result in high jump, which will impact the badminton player's punch quality. Flexibility in the wrist will also influence the blow[4]. Rapid direction changes, lunges, wrist flicks, and other explosive movements are necessary for badminton players. These repetitive motions might strain their tissues and result in damage[5].

Badminton is a fast-paced and dynamic activity that exerts a lot of stress on the upper extremities, particularly the wrist joint. Because badminton is a non-contact sport, injuries are most commonly caused by overuse and a lack of physical fitness training. The wrist, neck, and shoulder were the most often reported areas of concern for badminton players. They most frequently suffered injuries to their wrists. This could be due to frequent wrist flexion and extension when playing various types of shots. The majority of players who suffered from wrist pain also experienced shoulder and neck pain. Upper extremity injuries predominantly occur as the shoulder moves from the wind-up phase (starting phase) to acceleration phase. Research indicates a higher injury rate among athletes aged 18-25 years. This trend may be attributed to the younger player's lack of experience and their potentially more aggressive playing style[6].

Upper-extremity overuse syndromes from sports participation are quite common. It has been estimated that 50% of athletes will sustain injury, and 25% to 50% of these are from overuse. These syndromes are most frequently seen in racquet sports. Flexor carpi ulnaris (FCU) tendonitis is more common and has been reported in golf and racquet sports such as badminton [7]. A common ailment affecting the wrist joint is wrist tendonitis, which is characterized by tendon irritation and inflammation at the wrist joint. Wrist tendonitis is primarily caused by overuse or repeated movements. Numerous tendons surround the wrist joint. A tendon is a fibrous band of connective tissue that joins muscle to bone, enabling joint mobility. The wrist tendon joins the hand and finger bones to the forearm muscle. They fall into two categories: flexors and extensors. Tendons that run across the back and front of the wrist, respectively, are called extensors and flexors and they are responsible for bending the wrist backward and forward. Repetitive loading can induce injuries to tendon even though the load magnitude is within normal limits because the tendon does

not have enough time to heal before the next loading cycle. The primary pathogenic cause of degeneration is assumed to be excessive loading of tendons during intense physical exercise[8].

Repeated wrist motions and similar actions result in redness, swelling, and pain which indicates wrist tendonitis. Grasping or pinching motion exacerbates the pain, often accompanied by a cracking sound and a sensation of the thumb momentarily freezing in a position or locking. It is a typical overuse injury brought on by excessive compression and the corresponding storage and release of energy. In order to forecast risk variables and set up preventative measures to prevent damage, it is essential to comprehend the prevalence of injuries. The majority of the players have chosen badminton as their career. Assessing the degree of tendonitis will help to determine the treatment protocol for the players as well as raise awareness among coaches to design a better training plan. Hence lowering the chance of damage and raising the standard of instruction, which will improve the game.

A Research indicates that among badminton players, the most common sites of pain are the neck (75%), lower back and waist (81.2%), wrist (81.2%), knees (53.1%), and ankle (46.9%). The overall injury rate in this sport is 65.6%. Notably, when focusing on upper limb injuries, wrists are the most frequently affected area, with a prevalence of 90.6 % [9].

A flexibility program aims to improve range of motion (ROM) in major tendon groups to meet specific goals. While flexibility exercises are recommended 2-3 times weekly, daily practice offers optimal benefits. However, there is discussion about the best stretching methods or approaches to get the most improvement in flexibility [9]. For badminton players, task-specific exercises and wrist flexibility training have proven efficient in increasing wrist range of motion and minimizing the risk of injury. These methods focus on improving the wrist joint's range of motion, flexibility, and stability. Additionally, they aim to increase muscular strength and overall wrist movement, addressing the unique demands placed on badminton player's wrist. Wrist mobility was assessed using range of motion[10].

Therapeutic Ultrasound (TUS) is a widely used electro physical modality that produces mechanical energy, which travels through biological tissues. Physical therapists frequently employ ultrasound therapy to manage soft tissue injuries, with 98.0% considering it a crucial tool in their clinical practice. The application of ultrasound therapy varies depending on the target structure. Muscles are the most commonly treated (87.5%), followed by tendons (62.5%) and ligaments (39.6%). In contrast, therapists less frequently use ultrasound therapy on bursae and menisci (both 8.3%), and bones (6.3%). For treating deep tissues, physical therapists primarily opt for an ultrasound therapy frequency of 1 MHz However, both 1 MHz and 3 MHz frequencies are utilized for addressing superficial tissue injuries. Regardless of the injury type or tissue depth, the intensity of therapeutic ultrasound (TUS) typically ranges from 0.1 to 1.0W/cm². Therapists generally apply therapeutic ultrasound for durations between 2 and 4 minutes, with a preference for moving the equipment's head in circular motions during treatment[11].

Pulse mode Therapeutic Ultrasound is commonly used in the treatment of acute

conditions and continuous mode in chronic ones. The frequency of Therapeutic Ultrasound is selected depending on the depth of the targeted structure: 3 MHz frequency is used to treat surface structures, while 1 MHz is used for deeper (up to 5 cm) structures[12]. Therapeutic ultrasound, is an unfocused sinusoidal acoustic modality (< 3 W/cm2, continuous or pulsed mode), that has been used in both home and clinical settings to treat tendon injuries for decades. Low-intensity pulsed Ultrasound therapy exposure can induce non-destructive thermal and/or non-thermal effects to accelerate healing[13].

Contemporary Ultrasound therapy devices are capable of significant tissue heating. When applying 3-MHz ultrasound therapy at an intensity of 1.4 W/cm² for duration of 6 minutes to the wrist area, the local tissue temperature can be elevated to between 5°C and 6°C[14].

It is possible to have acute, subacute, or chronic tendonitis. Acute tendonitis symptoms last less than two weeks, subacute symptoms last between two and six weeks, and chronic tendonitis symptoms last more than six weeks. In tendon healing, the inflammatory stage occurs during the first 6 days, the fibroblastic/proliferative stage occurs from days 5 to 21 days, the remodelling/maturation stage begins on day 20. Treatment should include rest, ice, anti-inflammatory medications and decreased tension[15].

Mac Dermid et al. first described the Patient Rated Wrist Evaluation Score (PRWE) in 1998.The purpose of this questionnaire is to give a true and trustworthy method for measuring wrist discomfort as reported by patients in order to evaluate wrist range of motion, grip strength, and dexterity. The PRWE is divided into two components that examine function and pain from the patient's point of view. A 10-point, ordered, categorical scale, ranging from "no pain" or "no difficulty" to "worst pain" or "unable to do," is used to score each question. The tool was originally intended to assess wrist injuries[16].

Stretching has been shown to have positive biomechanical effects on the muscle-tendon unit, including enhanced strength and flexibility. In order to address the importance of wrist mobility and prevent wrist injuries in badminton players, a variety of training techniques have been studied. By doing certain stretching and strengthening exercises, the risk of overuse injuries can be decreased, muscle imbalance can be addressed and wrist flexibility can be increased. In badminton, wrist flexibility is essential for maintaining overall performance, providing power, and making accurate strokes[17].

However, because badminton moves are repetitive and forceful, players are more prone to wrist problems such as sprains, strains, and overuse injuries.

Objective: To determine the combined effect of Ultrasound therapy and Wrist flexibility training on wrist tendonitis among club level badminton players.

METHODOLOGY

Source of Data: Badminton Clubs in and around Bangalore – Kings Court Badminton Academy and Smash Hit Badminton Academy

Method of collection of data:

Type of study : Pre-Post Experimental study (Single group)

Population : Club level Badminton players

Sample size : 60 samples were selected for the study

Sample design : Convenience sampling used to allocate the samples in two Groups.

Study duration : The study conducted for duration of 6 Months

Inclusion Criteria: Club level Badminton Players with wrist tendonitis – diagnosed by Orthopaedician. Age group between 18 - 25 years, Both Male and Female, Subjects with NPRS between 3 to 7 (mild to moderate)

Exclusion Criteria: Any recent wrist surgeries or Fractures, Chronic conditions like severe arthritis, Any Cardiovascular conditions, psychological conditions, Players already undergoing wrist tendonitis treatment with any medication, Subjects with fixed wrist deformity, Players already participating in any other research studies involving Intervention, Non-cooperative subjects, Allergies to ultrasound gel used in the study, Occupational factors which have Repetitive wrist movements in jobs like typing, Driving etc.

Materials Required:

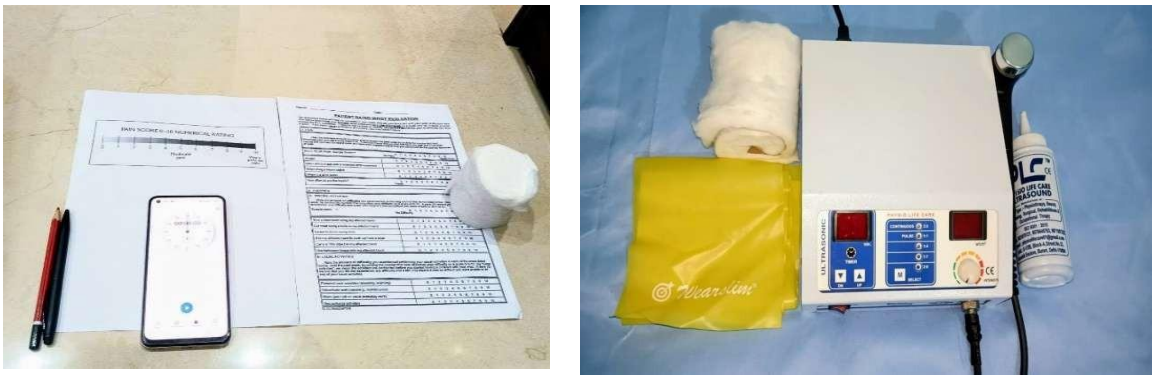

Figure1 Materials Used Pen /Pencil, Paper, Stop watch, PRWE form, Theraband, NPRS form, Portable Therapeutic ultrasound machine, Ultrasound gel, Cotton

METHODOLOGY

Ethical clearance for the study was obtained from the Institutional Ethical Committee under reference number PIEC/PIP/13/2024 dated 20/06/2024. Prior to participation, informed consent was obtained from each subject after explaining the study's purpose, procedures, and expectations in detail.

Procedure: A total of 60 subjects were selected through convenience sampling, based on predefined inclusion and exclusion criteria. All participants were club-level badminton players diagnosed with wrist tendonitis by an Orthopaedician and had a Numeric Pain Rating Scale (NPRS) score between 3 to 7, indicating mild to moderate pain. Baseline demographic data including name, age, height, weight, BMI and years of playing experience were recorded for all participants. A pre-test and post-test design was used to assess outcome,

focusing on pain and wrist function using the Patient-Rated Wrist Evaluation (PRWE) score. Ultrasound Therapy with Wrist Flexibility training was administered daily for four weeks: Each participant received pulsed-mode therapeutic ultrasound at an intensity of 0.6 to 1.0 W/cm² for a duration of 7 minutes daily. Following ultrasound therapy, players underwent 30 minutes of wrist flexibility training including:

Wrist extensor stretches, held for 15–30 seconds each. Flexor static stretches of the wrist, also held for 15–30 seconds each. Wrist circles, performed as 10 repetitions clockwise and 10 counter clockwise. Theraband resistance exercises for wrist flexion, extension, radial deviation, and ulnar deviation, with 10 repetitions per movement.

Outcome measures:

Procedure for PRWE Scoring: The Patient-Rated Wrist Evaluation (PRWE) score was used to evaluate both pain and functional disability from the participant's perspective. It is a self-administered questionnaire comprising 15 items, divided into two domains: pain (5 items) and function (10 items). Each item is scored on a 10-point scale, where 0 indicates no pain or difficulty and 10 indicates worst possible pain or complete inability to perform the task.

The pain score is the sum of five items, with a maximum of 50. The function score is the sum of ten items divided by 2, also yielding a maximum of 50. Hence, the total PRWE score ranges from 0 to 100, with higher scores reflecting greater pain and functional limitation. PRWE score assessments were conducted before and after the four-week intervention period.

Data Analysis:

The data on baseline characteristics and outcome measures were carefully collected and recorded. The data was analysed through statistical software SPSS version 23.0. Both descriptive and inferential statistical methods **w**ere used to interpret the results. Hence, the level of significance $\alpha = 0.05$.

- The Frequency and percentage analysis was used to describe the qualitative background variables of the subjects.
- The descriptive measures of range, mean, and standard deviation was used to describe quantitative background variables.
- The Wilcoxon signed-rank test was used to assess the pre-test and post-test differences in PRWE scores, which measured pain and wrist function before and after the intervention.
- Microsoft Word, MS -Excel and SPSS graphical editor were used to generate the tables and graphs to visually represent the data and findings.

RESULTS

Table-1 Gender proportion of club level Badminton players (n=60)

S.No.	Gender	No. (%)
1	Male	25(41.7)
2	Female	35(58.3)

The Table-1 represents the gender proportion of the club level badminton players. Out of a total of 60 club-level badminton players, 25 participants (41.7%) were male**,** and 35 participants (58.3%) were female**.**

Table-2: Description of Quantitative background variables of club level Badminton players (n=60)

S.No.	Background variables	Club level Badminton Players	
		Range	**Mean ±SD**
1	**Age in years**	20-25	22.88±1.48
2	**Height(m)**	1.51-1.69	1.58±0.047
3	**Weight(kg)**	40-70	53.05±8.85
4	**BMI**	16.14-30.26	21.19±3.24
5	**Years of playing**	1-7	3.97±1.83

The Table-2 outlines the description of quantitative background variables of the club level badminton players. Out of the total sample 60, the age range of Club level badminton players were 20-25 years, with the mean age of 22.88 and SD of 1.48. The range of height in club level badminton players were 1.51-1.69m with mean and SD of 1.58 ± 0.047. The weight ranged from 40-70kg with the mean and SD of 53.05 ±8.85 kg. Similarly, the range of BMI was 16.14-30.26 with the mean and SD of 21.19 ± 3.24. For years of playing experience, the range was 1-7 years with a mean and SD of 3.97 ± 1.83.

Table-3: Pre and post-test PRWE of Club level Badminton players with wrist tendonitis. (n=60)

S.No.	Outcome measures	PRWE		Wilcoxon test	p-value
		Range	**Mean ±SD**		
1	**Pre test**	50-65	58.63±3.76	z=6.746, S	p<0.001
2	**Post test**	19-39	27.12±5.46		

Note: S-Significant (p<0.05), z-Wilcoxon test

The Table-3 represents the outcome measures of PRWE (Patient-Rated Wrist Evaluation) scores pre and post-intervention among all 60 participants diagnosed with wrist tendonitis. The pre-test PRWE scores ranged from 50 to 65, with a mean and SD of 58.63 ± 3.76**,** indicating mild to moderate wrist-related pain and functional limitations at baseline.

Following the intervention, which included ultrasound therapy and structured wrist flexibility exercises, the post-test PRWE scores decreased significantly**,** ranging from 19 to 39, with a mean and SD of 27.12 ± 5.46**.** The Wilcoxon Signed-Rank Test revealed z-value of 6.746 with p-value < 0.001, confirming that the reduction in PRWE scores post-intervention was highly statistically significant**.**

DISCUSSION

The present study included 60 club-level badminton players between the ages of 18 to 25 years, all diagnosed with wrist tendonitis. The aim was to evaluate the effectiveness of a combined intervention of ultrasound therapy with wrist flexibility training over a four-week period. Outcomes were assessed using the Patient-Rated Wrist Evaluation (PRWE) score. The results demonstrated a statistically significant improvement in wrist pain and function post-intervention, with PRWE scores reducing with a mean and SD of 58.63 ± 3.76 in the pre-test to 27.12 ± 5.46 in the post-test ($p < 0.001$).

The demographic data of the sample (n=60) shows 41.7% males (n=25) and 58.3% females (n=35), showing a female-majority group. This reflected recent demographic trends observed in badminton at the club and recreational levels. The age range and gender proportion in this study is consistent with the previous study findings by Prasad et al. who conducted a study among 237 recreational badminton players in India and reported that among 237 participants, 62.9% were female and 37.1% were male players. The mean age of the participants was 23.5 years (SD: 5.95). The most affected age group was 18–25 years**,** and upper limb injuries were among the most frequently reported complaints [19-21].

Previous studies have also highlighted that wrist injuries are known to be more frequent in females due to anatomical and hormonal differences, including reduced muscle mass, increased joint laxity, and lower tendon loading thresholds. Prasad et al., reported that 8.9% of their sample had a BMI below 18.5 and was identified that BMI was a statistically significant predictor of injury risk. Their logistic regression analysis revealed that lower BMI was associated with a higher incidence of musculoskeletal complaints, emphasizing the role of body composition as a modifiable risk factor in overuse injuries [18].

Background variables also play an important role in determining injury risk. In this study, the mean weight was 53.05 with SD of 8.85 and the mean BMI was observed as 21.19 With SD of 3.24. The result of this study matches with the previous study which was conducted by Rettig who described that tendinopathies of the wrist are common in sports involving repetitive hand and wrist movements, and noted that both underweight and overweight athletes are at risk due to altered joint mechanics, excess body weight may increase loading across tendon surfaces during explosive movements, while low BMI may reduce cushioning during wrist extension and flexion.(7) However, the mean height was 1.58 with SD of 0.047 and the playing years ranged from 1-7 with mean 3.97 and SD of 1.83.

Wrist tendonitis results from the chronic overload of the flexor and extensor tendons crossing the wrist joint. Biomechanical analysis has identified that high-repetition, high-force motions such as smashes and backhands,

especially those involving rapid ulnar or radial deviation—is major contributors to tendinopathy in badminton (Rettig; Jafari et al.).The article by Jafari et al., reviewed that upper extremity injuries in racquet sports and concluded that repetitive, high-velocity wrist movements were a primary cause of tendinopathy**,** especially in the dominant hand [19]**.**

Therapeutic ultrasound is a widely used modality which is known for its thermal and non-thermal effects that promote soft tissue healing, reduce inflammation, and enhance collagen production—making it particularly effective in the treatment of tendon injuries. It has long been recognized as an effective modality for tendon rehabilitation and accelerates the repair process by increasing local blood circulation and stimulating Cellular activity within the tendon.

The study conducted by Smallcomb et al. found that combining ultrasound therapy with resistance exercise yielded significantly better tendon healing outcomes in athletes, including faster recovery and improved strength. It enhances tissue healing by increasing local blood flow and stimulating fibroblast activity. They also reported that combination of ultrasound therapy with exercise resulted in greater reduction in pain and function compared to either modality alone[20].

A systematic review by Cota et al. demonstrated that therapeutic ultrasound significantly improves tendon healing**,** pain, and function—especially when used in combination with their rehabilitation . The patients with chronic tendonitis showed 15–25% greater pain reduction than rehabilitation alone[21]. Wrist flexibility training with ultrasound therapy improves the range of motion, muscular coordination, and joint stability. Rubika et al., concluded that wrist mobility and injury prevention improved significantly when task-oriented exercises were combined with wrist flexibility protocols in badminton players. (3) Another study by, Peterson and Renström emphasized that regular flexibility training optimizes the muscle–tendon unit, improves joint mechanics, and prevents tendon overloading, making it a critical part of rehabilitation for overuse injuries. Thus, Stretching has been shown to positively impact the biomechanical properties of the muscle–tendon unit, improving both performance and injury resilience[22]. Thus, this study combined ultrasound therapy with wrist flexibility training for wrist tendonitis among club level badminton players which showed significant improvement in the condition.

The PRWE score was chosen for this study due to its strong validity and responsiveness and for its dual focus on pain and functional disability in wrist disorders. The previous study by Mehta et al., also reviewed that PRWE score is one of the most reliable patient- reported outcome measures for wrist function, with a high intra class correlation coefficient (ICC =0.85) and sensitivity to change[23]. The significant difference in pre- and post-test PRWE scores for the present study thus reflects a meaningful clinical improvement in the participants' pain and functional status.

Mac Dermid et al. validated PRWE as a reliable, sensitive, and patient-centered outcome measure. Its responsiveness to clinical changes in wrist conditions makes it an ideal tool for measuring the effectiveness of

therapeutic interventions in athletes[24]. The significant reduction in PRWE scores in this study reflects clinically meaningful improvement in pain and function.

The club-level badminton players should prioritize early physiotherapy when experiencing wrist pain. Incorporating ultrasound therapy with wrist flexibility training can significantly reduce pain and improve function. Flexibility exercises should be part of daily warm-ups and cool downs to prevent recurrence. Incorporating flexibility training like static stretches and Theraband exercises with ultrasound therapy will help in pain reduction and improved ROM. This approach supports quicker recovery and long-term wrist health in badminton athletes.

Additionally, de Brito Vieira et al., ultrasound therapy remains a widely utilized modality among physiotherapists for managing musculoskeletal injuries, particularly those involving tendons[26]. When paired with structured wrist flexibility exercises, the overall rehabilitation impact is enhanced through improvements in range of motion, neuromuscular control, and tendon resilience. The inclusion of flexibility exercises also supports injury prevention**,** a key concern in competitive and recreational badminton.

Rubika et al. highlighted the effectiveness of task-specific flexibility routines in reducing recurrence rates of wrist injuries. Similarly, Peterson and Renström emphasized that regular stretching improves tendon compliance, reduces mechanical strain, and lowers the likelihood of chronic overuse injuries [27].

These findings suggest that the intervention used in the current study can be incorporated not only as a rehabilitative tool but also as part of preventive programming**,** such as athlete warm-ups, cool downs, or off-season conditioning plans.

CONCLUSION

The current study concludes a significant positive effect of combining ultrasound therapy with wrist flexibility training in reducing wrist pain and improving function among club-level badminton players with wrist tendonitis with significance of p value($p<0.001$) by Wilcoxon signed rank test.

A significant improvement was observed in the Patient-Rated Wrist Evaluation (PRWE) scores following a four-week intervention, which supports the Alternate hypothesis stating that there will be a significant effect of Ultrasound therapy and Wrist flexibility training on wrist tendonitis among Club-level Badminton players demonstrating the clinical value of this combined approach. As, Ultrasound therapy is known for its deep-tissue healing properties, combined by targeted wrist flexibility exercises, collectively contributed to enhanced tendon recovery and joint mobility. These combined therapy proved effective in addressing the demands placed on the wrist by repetitive badminton movements such as smashes, flicks, and drives.

As there is high incidence of wrist overuse injuries in young badminton athletes, the findings support the use of this conservative, non-invasive method as a practical solution for managing wrist tendonitis. The outcome not only highlights therapeutic benefits but also emphasizes the role of structured physiotherapy in promoting functional

recovery and safe return to sport in competitive settings.

Limitations:

1. The study lacked a control or placebo Group, which limits the ability to determine the isolated effects of ultrasound therapy and wrist flexibility training.

2.The research was limited to short duration which restricts the understanding of long-term effects, recurrence rates, or sustained functional improvement beyond the treatment.

3.The study focused only on club-level badminton players aged 18–25 years, which may limit the applicability of findings to other age groups or professional athletes.

Recommendations:

1. Future studies can incorporate a randomized control group to isolate the individual contributions of ultrasound therapy and flexibility training, thereby enhancing internal validity.

2. Future studies can also include additional outcome measures such as Hand Dynamometer, Grip strength tests and functional performance.

3. More studies exploring the dose- response effect of ultrasound therapy which can include different mode, frequencies and intensities.

Further studies can include long term efficiency and recurrence rates and extend the intervention duration to 8-12 weeks which includes follow up phase.

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