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Research Article

Effect of friction massage and post facilitation stretch in relieving symptoms related to upper cross syndrome: A randomized clinical trial

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ABSTRACT

Background: Upper Cross Syndrome (UCS) is a postural dysfunction that often results from prolonged poor posture, associated with neck pain, shoulder discomfort, reduced range of motion, and muscle fatigue, and significantly impacts daily activities and quality of life. Friction massage (FM) and post-facilitation stretch (PFS) are gaining attention for their potential effectiveness in relieving symptoms and improving muscular balance.

Objective: to determine the effectiveness of friction massage and post-facilitation stretch (PFS) in relieving symptoms of the upper cross syndrome (UCS).

Methods: A randomized clinical trial was conducted on n=60 participants of both genders aged 20-50 years, diagnosed cases of upper cross syndrome. All participants were divided into Group A received friction massage (FM) while Group B received post-facilitation stretch (PFS) in addition to conventional physical therapy (CPT). Each participant received one month of intervention. The data was collected through a visual analog scale (VAS) and neck disability index (NDI) at the baseline, after the 2nd week, and 4th week.

Results: The mean age of the n=60 participants was 42.23±9.15 years. The results of RM-ANOVA showed significant improvement ($p<0.001$) in pain intensity and neck disability in both groups at each level of assessment till at the end of 4th week of intervention. While comparing both groups, no significant difference ($p\geq0.05$) was observed between the groups throughout the treatment duration.

Conclusion: The friction massage and PFS were equally effective in improving neck pain and disability in patients with UCS having the distinct mechanism of action, may be overshadowed by Conventional physical therapy.

Keywords: *disability; friction massage; muscle energy technique; neck pain, pain, post facilitation stretch; upper cross syndrome.*

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INTRODUCTION

Upper Cross Syndrome (UCS) is a postural dysfunction that often results from prolonged poor posture, is associated with neck pain, shoulder discomfort, reduced range of motion, and muscle fatigue, and significantly impacts daily activities and quality of life[1]. It often results from repetitive tasks and involves tightness in the upper trapezius, levator scapulae, and pectoralis minor, coupled with weakness in the middle trapezius and serratus anterior leading to prolonged poor posture[2]. Sometimes it is associated with temporomandibular dysfunction as well, showing a complex relation between neck posture and TMJ biomechanics[3].

Physical therapy in Upper Cross Syndrome (UCS) is indicated to address muscular weakness and postural deviations[4, 5]. Different therapeutic interventions including muscle energy techniques (METs) and therapeutic exercises, have shown significant effects in reducing pain, range of motion, and disability among patients[2, 6, 7]

THE deep friction massage is also used to break down adhesions, increasing circulation, and decreasing muscular tightness[8]. The literature has suggested that deep friction massage can be effective for managing the myofascial pain syndromes, tendinopathies, and muscle tightness by improving localized blood flow and decreasing muscle spasm[9, 10]. The friction massage may also help alleviate muscle tightness in the upper trapezius and pectorals, potentially reducing pain and improving the range of motion in patients with upper cross syndrome[10].

Post-facilitation stretch (PFS), which is a muscle energy technique (MET) technique significantly increases flexibility, decreases stiffness, improves neuromuscular function, and is useful for addressing muscle imbalances in UCS[11, 12]. Both the muscle Energy Techniques (MET) and deep friction massage show different effects on pain reduction and range of motion improvement in patients with UCS[13].

There are several methods available for the management of upper cross syndrome in literature, but the comparison between deep friction massage and post-facilitation stretching (PFS) has not yet been explored. Moreover, no study was found specifically investigating the PFS application for UCS. Given these gaps, the objective of this study is to compare the effects of both friction massage and post-facilitation stretching in reducing UCS symptoms. The study could contribute to establishing evidence-based protocols, promoting both patients and healthcare professionals.

METHODOLOGY

Study design: A two-arm, double-blinded, randomized clinical trial was conducted from June 2023 - December 2024 at Physical Therapy department of Halima Siraj Hospital Rawalpindi, after approval (Ref # HSH/062023-4) from Medical Director. Informed consent was obtained from all the study participants and assuring the confidentiality of the privacy according to the Deceleration of Helsinki. The purpose of the study was explained to all the participants before the study.

Participants: The participants of both genders aged between 20-50 years, diagnosed cases of the upper cross syndrome, and showed a willingness to participate, were included in the study. However, participants with any inflammatory disease, cervical spine trauma, cervical spine tumors, cervical spine instability, and open wounds and scars were excluded from the study.

Sample size: The total sample size of n=62 participants is required to achieve a power of 80% for detecting a medium effect size (F=0.3) and a significance level (α) of 0.05. A total of n=86 subjects were evaluated for eligibility and due to accessibility n=26 did not participate in the study. Finally, the data of n=60 participants were randomly allocated to group A (n=30) and group B (n=30) and analyzed. (Figure 1)

Randomization & blinding: Randomization was done through the lottery method and participants were divided into two groups group A, and Group B (n=30 participants in each group) as shown in figure Randomization was done by the person who wasn't directly involved in the study. The study was double-blinded; thus, the therapist and the patient were kept blind. Patients were unaware of the other treatment procedures while treating physiotherapists were blinded to the assessment, which was done by the other researcher.

Intervention: All participants in both groups received conventional physical therapy (CPT) including TENS therapy for pain relief, administered 3 times per week for 15 minutes. Ultrasound therapy was also incorporated 3 times per week for 7 minutes, primarily targeting tight muscles like the pectorals and upper trapezius to aid in muscle relaxation. Finally, The strengthening exercises including Chin tucks, which strengthen the deep cervical flexors, were performed 3 times per week in 3 sets of 10–12 repetitions. Moreover, scapular stabilization exercises such as Y, T, and W exercises were prescribed 3 times per week with 3 sets of 10 repetitions to enhance the function of the lower trapezius and rhomboids. (Figure 2)

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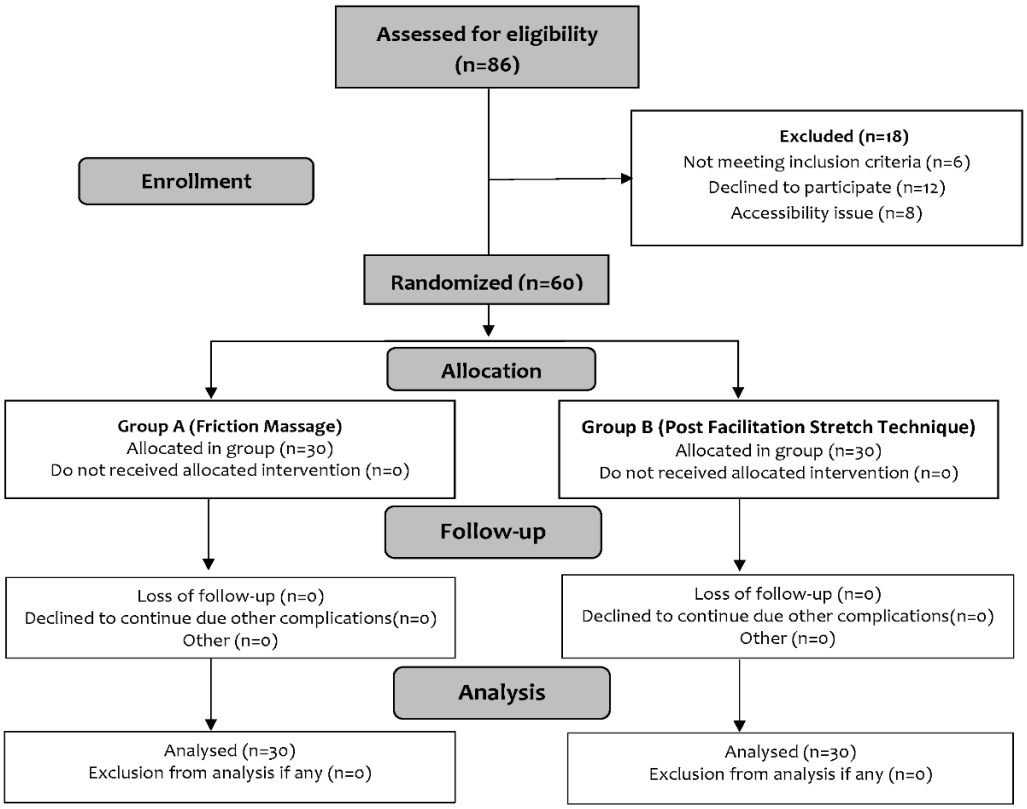

Figure 1: Consort Diagram

In addition to CPT, group a received 3 sessions/week of friction massage (FM) for four weeks with moderate pressure for 10-15 minutes per area (Upper trapezius, levator scapulae, and pectorals) in a single session to release muscle adhesion and improve circulation. Group B also received 3 sessions/week for a four-week, post-facilitation stretch (PFS) with gentle to moderate contraction of the upper trapezius, levator scapulae, and pectorals followed by a 30-sec passive stretch of 2-3 sets in each session.

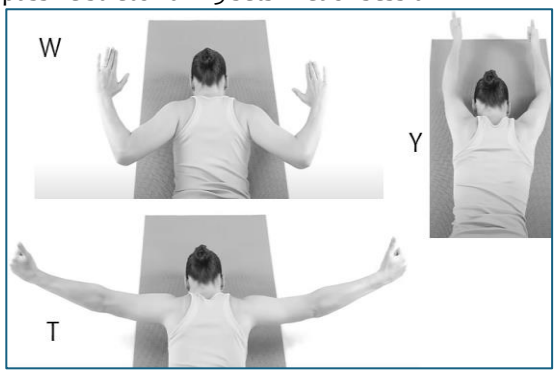

Figure 2: Y, T and W Exercises for lower trapezius and Rhomboids

Data collection: The demographic data in terms of age, gender, and BMI were collected at the baseline. The Visual Analogue Scale (VAS) was used to determine the pain, and The Neck Disability Index (NDI) was used to determine the level of disability. The data of outcome measures were collected at baseline, 2nd week, and after 4th week.

Data analysis: For the descriptive statistics, mean, standard deviation, frequency, and percentages were used. To evaluate within-group effectiveness, RM-ANOVA was used, while an independent t-test was used for between-group differences at each assessment level. The data was analyzed through SPSS version 26 and the level of significance was set at $p<0.05$.

RESULTS

The mean age of the n=60 participants was 42.23±9.15 years. A total of n=19 participants were males and the remaining n=41 were females. Most of the participants had a healthy weight range (23.96±4.13 kg/m2). The frequency distribution can be seen in figure 3

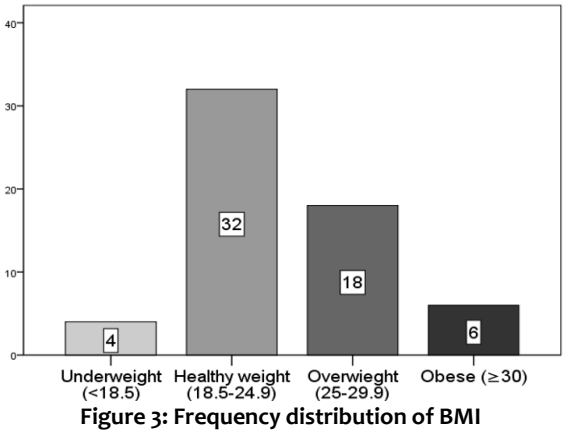

Figure 3: Frequency distribution of BMI

The results of RM-ANOVA showed significant improvement ($p<0.001$) in pain intensity and neck disability in both groups at each level of assessment till at the end of 4th week of intervention.

Table 1: With-in group changes (VAS & NDI)

		Group A (Friction Massage)				Group B (Post Facilitation Stretch Technique)			
		Mean	SD	MD/F(df)	p-value	Mean	SD	MD/F(df)	p-value
VAS	Baseline	6.43	1.69	1.76	[a]0.001***	6.24	1.86	1.77	[a]0.001***
	After 2nd week	4.67	1.70	3.68*	[b]0.001***	4.47	1.79	3.71	[b]0.001***
	After 4th week	.98	1.03	260.77(1.03, 30.13)	[c]0.001***	.75	.82	218.75(1.03,30.04)	[c]0.001***
NDI Score	Baseline	22.27	12.22	14	[a]0.001***	17.67	9.05	9.56*	[a]0.001***
	After 2nd week	8.27	10.07	1.800*	[b]0.001***	8.10	7.54	1.76	[b]0.001***
	After 4th week	6.47	9.43	56.19(1.01, 29.28)	[c]0.001***	6.33	7.09	40.81(1.01,29.31)	[c]0.001***

Significance level: p<0.05, p<0.01**, p<0.001*** [a]baseline versus 2nd week, [b]2nd week versus 4th week, [c]baseline versus 4th week; VAS-Visual Analogue Scale; NDI-Neck disability Index; SD- Standard Deviation; MD-Mean Difference; df-Degree of freedom*

While comparing both groups, no significant difference (p≥0.05) was observed between the groups throughout the treatment duration. (Table 2)

Table 2: Comparison between groups (VAS & NDI)

		Group A (Friction Massage)		Group B (Post Facilitation Stretch)		MD	p-value
		Mean	SD	Mean	SD		
VAS	Baseline	6.43	1.693	6.24	1.860	.193	.675
	After 2nd week	4.67	1.709	4.47	1.795	.200	.660
	After 4th week	.98	1.030	.75	.821	.230	.343
NDI	Baseline	22.27	12.228	17.67	9.057	4.600	.103
	After 2nd week	8.27	10.079	8.10	7.549	.167	.942
	After 4th week	6.47	9.438	6.33	7.097	.133	.951

Significance level: p<0.05, p<0.01**, p<0.001****

VAS- Visual Analogue Scale; NDI-Neck disability Index; SD- Standard Deviation; MD-Mean Difference; df-Degree of freedom

DISCUSSION

The aim of the study was to determine the effectiveness of friction massage and post-facilitation stretch in improving pain and disability measured through VAS and NDI. It was hypothesized that friction massage is more effective as compared to PFS. However, the results of the study didn't show any significant difference between both interventions in improving pain and disability.

In a recent study, friction massage significantly improved pain and disability from baseline to follow-ups of 4 weeks in upper cross syndrome. The possible reason for the reduction in pain is traumatic hyperemia induced by friction massage, which reduces pain metabolites. Also, it destroys adhesions and optimizes the quality of scar tissue and mechanoreceptor stimulation, which produces afferent impulses that stimulate temporary analgesia [8, 14]. These factors may contribute to a decrease in pain and thus reduce pain-related disability and improve the patient's functional status[14]. Similar findings were observed in the literature, highlighting the manual therapies effectiveness, including massage, for the management of pain and improvement in functional outcomes in wide musculoskeletal conditions[15, 16].

Furthermore, significant improvement was observed in pain and disability after post-facilitation stretch throughout the treatment duration. The improvement may also be due to the inhibition of Golgi tendon, which occurred after stretching that relax the muscles and significantly reduces the pain[17]. Post-facilitation stretch relaxes muscles after maximum stretch, which decreases pain and may leads to improved pain-related disability[18, 19].

When comparing differences between groups, both interventions showed significant improvement and no difference was found between groups in pain and disability, may be due to similar physiological effects[15, 20, 21] The inclusion of conventional physical therapy (CPT) in both groups may have confounded results by contributing equally to pain and disability reduction[22]. Additionally, overlapping benefits of interventions could have further masked differences[23].

As per results and discussion, conventional physical therapy confounded the results, If the strengthening component which is already a comprehensive protocol for posture correction may overshadow the effect of both interventions.

CONCLUSION

Both friction massage and post-facilitation stretch improved pain and disability equally. These findings may be due to CPT, which likely contributed equally to symptom improvement in both groups as a confounder. Future studies should be without conventional Physical Therapy to avoid overlapping effect, use larger sample sizes, and measures to better distinguish the independent effects of these interventions.

DECLARATIONS & STATEMENTS

Author's Contribution

ZA: substantial contributions to the conception and design of the study.
ZA and MA: acquisition of data for the study.
ARS and KB: analysis of the data for the study.
ZA, ARS and MA: interpretation of data for the study.
ZA, KB: drafted the work.

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ZA, ARS, KB and MA: revised it critically for important intellectual content.
ZA, ARS, KB and MA: final approval of the version to be published and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors contributed to the article and approved the submitted version.

Ethical Statement

The study was conducted from June 2023 - December 2024 at Physical Therapy department of Halima Siraj Hospital Rawalpindi, after approval (Ref # HSH/062023-4) from Medical Director. Informed consent was obtained from all the study participants and assuring the confidentiality of the privacy according to the Deceleration of Helsinki

Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments

None to declare.

Conflicts of Interest

The authors declare no conflict of interest.

Funding

None to declare.

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Research Article

Effects of isometric muscle training on shoulder pain, function and performance in bowlers: A randomized clinical trial

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Abstract

Background: Overuse injuries with shoulder pain are one of the most common complaints among cricket bowlers, leading to reduced performance, and ultimately affecting an athlete's career and overall well-being. Isometric muscle training (IMT) is gaining attention as an effective intervention for musculoskeletal pain and functional performance.

Objective: To determine the effects of isometric muscle training on shoulder pain, function, and performance in bowlers.

Methods: a single-blind, randomized controlled trial was carried out from July 2023 to June 2024 on active male bowlers between the ages of 18 and 30, who suffered from pain and discomfort in the rotator cuff muscle. A total of n-36 bowlers were randomly allocated to Group A and received isometric exercises focused on shoulder flexion, extension, abduction, adduction, internal rotation, and external rotation. Group B underwent conventional physical therapy exercises, including open and closed kinetic chain shoulder exercises, active ROMs, and stretching. The Visual Analogue Scale (VAS) and Disability of Arm, Shoulder, and Hand (DASH) Questionnaire were used for pain and disability, respectively. The assessment was done at baseline, after 2nd week and 4th week.

Results: The results showed that IME had a significant effect ($p<0.5$) on pain reduction, functional recovery, and sports-specific performance compared to CPT except for speed ($p\geq0.05$). The result of IME became evident from the 2nd week for pain and overall function, while in sports-related function, IME appeared significant ($p<0.05$) by the 4th week.

Conclusion: Isometric exercises are highly effective for managing shoulder pain and improving functional capacity in bowlers, particularly in reducing disability and enhancing sports-specific performance over time.

Keywords: cricket bowlers; conventional physical therapy; disability of arm shoulder and hand (DASH); functional performance; isometric exercise; rotator cuff; scapular stabilization; shoulder pain; visual analogue scale (VAS)

Clinical Trial # NCT06426875

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INTRODUCTION

The shoulder is the ball and socket joints, which provide the shoulder a great range of motion but also make it more prone to injury because of its instability [1, 2]. The muscles that directly support the shoulder are the rotator cuff, which support movement, and serve as stabilizers to maintain the stability of joints. Bowling puts a lot of strain on the shoulder muscles, due to the repeated, high-intensity movements indicative of shoulder overuse and therefore induces shoulder discomfort, appropriate therapy interventions.

However, because of its complexity, the shoulder is more prone to injury, particularly while engaging in physically demanding sports like bowling [3, 4]. In bowlers' eccentric loads placed on the shoulder muscles often lead to rotator cuff injuries, impingement syndromes, and scapular dyskinesia [5, 6]. The shoulder resilience and pain reduction related to this condition can be achieved through targeted scapular muscle stabilization training in overhead-throwing athletes [7-9].

The effects of eccentric and concentric training have been widely available in the literature [10-12], but emerging evidence suggests a positive role of isometric exercises in improving the stability of the shoulder joint and its neuromuscular control [13, 14]. Isometric exercises enhance proprioception and muscle activation, which are critical for shoulder function in high-demand sports and help in reducing pain and improve shoulder function in patients with impingement syndrome [15, 16].

Despite these findings, research examining the effects of isometric training on bowlers remains limited. Most literature results from other overhead sports, but cricketers experience different stressors on the shoulder joint, so failing to justify due to the unique biomechanics and loading patterns. So, targeted research is necessary to determine the effects of isometric muscle training on shoulder pain, function, and performance in cricket bowlers.

MATERIALS AND METHODS

Study Design: A single-blind, randomized controlled trial was carried out at the City Cricket Club in Rawalpindi, Pakistan (CCC/July/24-01). The study was approved by the research and ethical committee and completed in a year, from July 2023 to June 2024 (REC) of the Faculty of Rehabilitation and Allied Health Sciences (Ref# Riphah/RCRAHS-ISB/REC/MS-PT/01834) Riphah International University.

Selection Criteria: Non-probability convenient sampling technique was used for sample collection. Active male bowlers between the ages of 18 and 30, who suffered from subacute pain and discomfort in the rotator cuff muscle, were included in the study. On the other hand, the batsman was excluded.

Sample size: A sample size of n=36 was determined using G*Power software, assuming a small effect size (0.25) and an error rate of 0.05. To minimize the β error probability, the power (1-β) was set at 0.90. Out of n=50 patients assessed for eligibility, n=36 met the inclusion criteria and were randomly assigned to either group A (n=18), which received Isometric Exercises, or group B (n=18), which received Conventional Therapy. There were two (n=2) losses of follow-up in both groups. By the end of the study, a total of n=34 participants were analyzed. (Figure1)

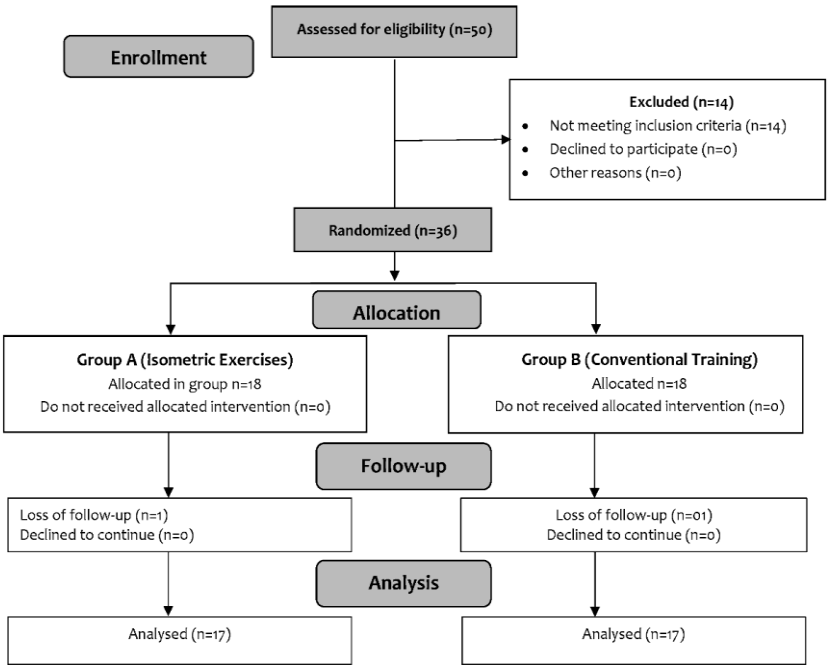

Figure 1: CONSORT Diagram

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Randomization: The sealed enveloped method using a computerized random number generator (Research Randomizer) was used for randomization. The allocation at random was done out by a person that had no direct involvement in the research. Prior to the commencement of the trial, a big opaque sealed envelope containing cards with randomly picked numbers was sealed. The physical therapist opened the package and gave the patients the prescribed treatments after obtaining written informed consent. Because the evaluating physical therapist was blind to the therapies the patients underwent, the trial was conducted in a single-blinded fashion.

Intervention: Group A Isometric Training Group The isometric exercise program focuses on shoulder flexion, extension, abduction, adduction, internal rotation, and external rotation using TheraBands. The program is performed three times weekly, with a therapist's supervision. Participants receive correct instruction, and their development is closely evaluated for safety and effectiveness. Group B underwent conventional physical therapy exercises, including open kinetic chain shoulder exercises, closed kinetic chain shoulder exercises, active ROMs, and stretching. Open kinetic chain exercises involved shoulder presses, while closed kinetic chain exercises involved push-ups and wall push-ups. Active ROM exercises included arm circles, cross-body shoulder stretches, and doorway stretches. Participants received correct form and technique instruction throughout the intervention, and their development was closely evaluated to ensure safety and effectiveness. The protocol included arm circles, cross-body shoulder stretches, and doorway stretches. (Table 1)

Table 1: Detail Intervention Protocol

	Isometric Exercises (IME)	Conventional Training (CT)
Week 1 & 2	a) Isometric External Rotation (Perform isometric external rotation exercises with a resistance band to strengthen the rotator cuff), hold each contraction for 10-15 seconds. b) Isometric Internal Rotation (Hold each contraction for 10-15 seconds) c) Isometric Abduction (Supraspinatus). (each contraction for 10 -15 sec), 10 repetition 3 sets, Isometric Adduction (Subscapularis)	a) Open Kinetic Chain Shoulder Exercises 10 reps of 3 sets b) Closed Kinetic Chain Shoulder Exercises 10 repetitions and 3 sets
Week 3 & 4	a) Overhead Isometric Holds (Hold each contraction for 15-20 seconds) b) Isometric Shoulder External Rotation Against Resistance: (Hold each contraction for 15-20 seconds) c) isometric Shoulder Press (Hold each contraction for 15-20 seconds), 15 to 20 repetitions 4 sets	a) AROM 10 repetitions and 3 sets b) Stretching holding for 15- 30 seconds for 10 times

Assessment: The Visual Analogue Scale (VAS) was used to measure the pain intensity. The shoulder functions were evaluated through Disability of Arm Shoulder and Hand (DASH) Questionnaire. An Android smartphone with a high frame rate camera having ≥60 FPS was used to record the ball's motion. The BowloMetre, a bowling speed app was set up to utilize the smartphone camera and sensors to estimate speed. The distance between the bowler's release point and the batter is set to 20.12 meters, which is the usual cricket pitch length. The recordings were made in a controlled location, a cricket pitch, to exclude external influences such as wind and uneven surfaces. To guarantee constant recording settings, obtained during daytime, the Android smartphone was put on a tripod, perpendicular to the pitch and a fixed distance from the bowler's release point. Each bowler delivered 24 balls at their utmost speed to duplicate the match situation. Bowlers were asked to employ their natural bowling style without refraining from intentionally altering their speed or technique throughout the trials. The software tracked the ball's movement from the bowler's hand to the batter and calculated its speed using the formula; Speed=Distance/Time, where distance was a fixed 20.12 meters and time was the period monitored by the app.

Statistical methods: Descriptive statistics was used as mean, standard deviation, frequency, and percentages for numerical and categorical respectively. The Mixed ANOVA was conducted to determine the interaction effect between the intervention and the assessments. Between the group analyses for main effects, independent t-test and while for within-group analysis RMANOVA with pairwise comparison were used. The effect size was explained through partial eta and Cohen's d. The level of significance was set at 0.05. The SPSS Ver. 26 was used for data analysis.

RESULTS

A total of n=34 bowlers, mean age of participants was 21.3±2.26 years. Majority

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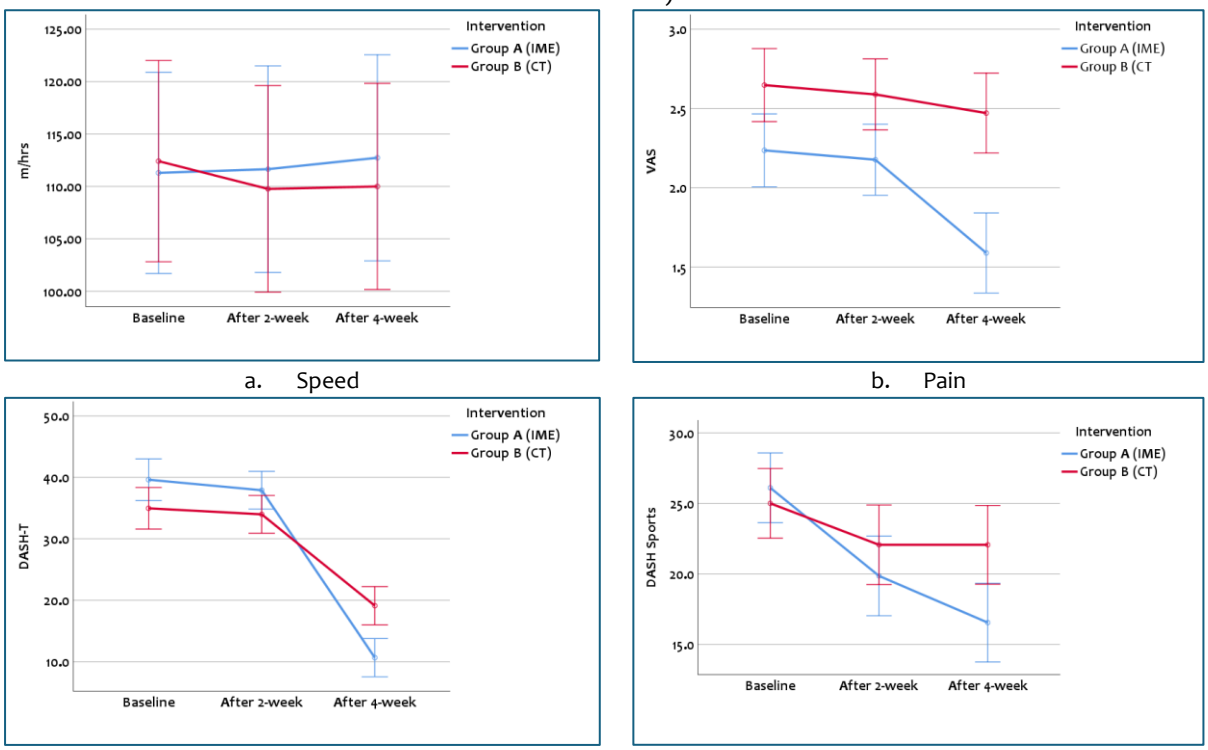
participants were in the normal BMI range with a mean BMI of 23.5±3.26 kg/m^2.

A Mixed ANOVA was conducted to examine interaction effect of isometric muscle training and CPT on shoulder function and performance on bowlers over a 4-week period. The main effect of isometric was found to be non-significant for speed (p=0.52) and significant for VAS (F=3.53, np^2=0.09, p=0.04), DASH-total (F=14.89, np2=0.3111, p<0.001), DASH-Sports (F=8.97, np^2=0.219, p=0.001). (Figure 2)



a. Speed b. Pain

c. Shoulder disability (General) d. Shoulder disability (Sports)

Figure 2: Interaction Effects (Intervention*Time)

The results of the repeated measures ANOVA (RMANOVA) or speed, the IME group showed a significant improvement across time points ($p<0.001$, $\eta p^2=0.752$), with a large effect size. The pairwise comparisons revealed a significant increase in speed from baseline to the 2nd week ($p=0.018$), and between the 2nd and 4th weeks ($p<0.001$). However, in the CT group, no significant ($p=0.80$) changes were observed over time.

The pain measured using the Visual Analog Scale (VAS), the IME group demonstrated a significant reduction in pain over time ($p=0.003$, $\eta p^2=0.408$), representing a medium to large effect. Pairwise comparison indicated significant pain reduction after the 2nd week ($p=0.011$). In contrast, the CPT group did not experience a significant reduction in pain over time ($p=0.39$).

Regarding functional disability, both the IME and CPT groups showed significant improvements over time on the Disabilities of the Arm, Shoulder, and Hand (DASH-Total) score. The IME group exhibited a highly significant reduction in disability scores ($p<0.001$), $\eta p^2=0.88$), indicating a very large effect size. Similarly, the CPT group also showed a significant improvement ($p<0.001$, $\eta p^2=0.92$), with pairwise comparison confirming significant improvements across all time points ($p<0.001$).

For sports-specific functional disability (DASH-Sports), the IME group showed a significant improvement over time ($p<0.001$, $\eta p^2=0.64$), with a large effect size. The pairwise comparison confirmed significant changes between all-time points ($p<0.001$). The CPT group also exhibited significant improvement ($p=0.01$, $\eta p^2=0.31$), indicating a moderate effect size. Pairwise comparison revealed that changes were statistically significant ($p = 0.047$) across all comparisons.

The results from the independent t-test indicate that all variables were comparable at the baseline. For speed, there was no significant difference (p≥0.05) between the Isometric (IME) and CPT groups at any time point. For pain levels by the end of 2nd week, the IME group reported significantly lower (p=0.013), pain compared to the CPT group, and the effect became more pronounced (p<0.001) by the end of 4th week, where the IME group demonstrated a highly significant reduction in pain. Regarding functional disability (DASH-Total scores), by the 2nd week, the IME group showed a statistically significant improvement (p<0.001). This trend continued by

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the 4th week (p<0.001) compared to the CPT group. For sports-specific disability (DASH-Sports scores), no significant difference was observed between groups at the 2nd week (p=0.26). However, by the 4th week, the IME group demonstrated a significant (p<0.001) improvement compared to CPT, suggesting that IME was more effective in improving sports-related functional outcomes in the later phase of the intervention. (Table 3)

Table 2: Repeated measure for Variables

Variable		Group	Baseline	2nd week	4th week	p-value	F(df)	np2
			Mean±SD	Mean±SD	Mean±SD			
Speed	IME	-	111.29±19.9	111.64±19.7	112.73±19.9	0.00***	48.62 (1.58)	0.75
		p-value	0.018*[a]	0.00***[b]	0.00***1[c]	-	-	-
	CT	-	112.41±18.8	109.76±20.1	110.0±19.8	0.808	0.21 (1.0)	0.01
		p-value	1.000[a]	0.124[b]	1.000[c]	-	-	-
VAS	IME	-	2.23±0.43	2.17±0.39	1.58±0.50	0.003**	11.03 (1.14)	0.41
		p-value	0.997[a]	0.011*[b]	0.011*[c]	-	-	-
	CT	-	2.64±0.49	2.58±0.50	2.47±0.51	0.397	0.86 (1.40)	0.05
		p-value	1.000[a]	0.490[b]	0.808[c]	-	-	-
DASH-Total	IME	-	39.62±8.82	37.90±7.83	10.66±6.92	0.00***	126.85 (1.18)	0.89
		p-value	0.031*[a]	0.00***[b]	0.00***	-	-	-
	CT	-	34.96±3.99	33.98±3.99	19.11±5.62	0.00***	207.74(1.64)	0.93
		p-value	1.000[a]	0.00***[b]	0.00***[c]	-	-	-
DASH-Sports	IME	-	26.10±7.06	19.85±6.71	16.54±6.60	0.00***	28.56 (1.69)	0.64
		p-value	0.00***[a]	0.00***[b]	0.00***[c]	-	-	-
	CT	-	25.0±0.0	22.05±4.48	22.05±4.48	0.016*	7.31 (1.0)	0.31
		p-value	0.047*[a]	0.047*[b]	0.047*[c]	-	-	-

[a]Baseline to 2nd week, [b]2nd week to 4th week & [c] baseline to 4th week
*Significance Level: p<0.001***, p<0.001**& p<0.05**
IME- Isometric Exercises; CT- Conventional Training; SD- Standard Deviation; df-Degree of freedom; VAS: Visual Analogue Scale, DASH: Disability of Arm, Shoulder and Hand

Table 3: Independent T test between groups for Speed, VAS and DASH-T and DASH-S

Variable	Group	Baseline			2nd week			4th week		
		Mean±SD	p-value	MD	Mean±SD	p-value	MD	Mean±SD	p-value	MD
Speed	IME	111.29±19.9	0.414	-1.11	111.64±19.7	0.965	1.18	112.73±19.9	0.855	2.73
	CT	112.41±18.8			109.76±20.1			110.0±19.8		
VAS	IME	2.23±0.43	0.153	-0.41	2.17±0.39	0.013*	-0.41	1.58±0.50	000***	-0.88
	CT	2.64±0.49			2.58±0.50			2.47±0.512		
DASH-Total	IME	39.62±8.82	0.056	4.65	37.90±7.83	000***	3.92	10.66±6.92	000***	8.45
	CT	34.96±3.99			33.98±3.99			19.11±5.62		
DASH-Sports	IME	26.10±7.06	0.525	1.10	19.85±6.71	0.268	-2.20	16.54±6.60	000***	-5.51
	CT	25.0±0.0			22.05±4.48			22.05±4.48		

VAS: Visual Analogue Scale, DASH: Disability of Arm, Shoulder and Significance Level: p<0.05, p<0.01**, p<0.001****
IME- Isometric Exercises; CT- Conventional Training; SD- Standard Deviation; MD-Mean Difference; df-Degree of freedom

DISCUSSION

The study evaluated the effects of isometric muscle training on shoulder pain, functions, and speed in bowlers. The result revealed that isometric exercise (IME) and conventional training (CT) both improved in pain reduction and sport-specific function compared to conventional physical therapy (CPT). While IME did not significantly enhance bowling speed relative to CPT, it demonstrated substantial benefits in reducing pain (VAS) and improving both general (DASH-Total) and sports-related (DASH-Sports) shoulder function, particularly by the 4th week. The significant pain reduction in the IME group (p=0.003) may be attributed to neuromuscular adaptations and reduced tendon sensitization, as isometric training has been shown to modulate pain pathways in tendinopathy [17]. This aligns with studies on overhead athletes, where isometric exercises improved rotator cuff stability and reduced subacromial impingement symptoms [15, 18].

Sustained isometric exercise activates descending inhibitory pathways leading to pain relief [19]. Moreover, increases local blood flow, promoting the clearance of metabolic by-products that contribute to pain and muscle fatigue, allowing athletes to perform rehabilitation exercises more effectively without exacerbating their symptoms[20].

The superior functional outcomes (DASH-Total and DASH-Sports) in the IME group underscore its potential to enhance shoulder stability and endurance, critical for bowlers who repetitively load the shoulder during delivery. Recent researches emphasize that isometric training improves force transmission across the rotator cuff, thereby mitigating functional disability [15, 21]. In contrast, CT's moderate effects on DASH-Sports

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(p=0.016) may reflect a focus on general mobility rather than sport-specific demands. Isometric exercises enhance the co-contraction of stabilizing rotator cuff muscles, improve muscular endurance and motor control, and lead to better load distribution and force efficiency, which is crucial for bowlers who require repeated high-velocity arm movements [15, 22].

The lack of speed improvement in both groups suggests that bowling speed relies on dynamic, sport-specific mechanics, which may not be directly targeted by static isometric protocols [23].

In contrast, open kinetic chain (OKC) exercises may not provide sufficient joint stability, and closed kinetic chain (CKC) exercises may lead to compensatory movement patterns that could aggravate pain or dysfunction [24]. Isometric exercises stimulate collagen synthesis, improving the resilience and capacity of tendons over time [25]. While CT including OKC and CKC exercises is valuable in later rehabilitation stages, it involves joint motion that may exacerbate symptoms in the acute phase of recovery [26].

Research indicates that isometric training strengthens the neuromuscular pathways responsible for force transmission, thereby reducing functional disability and improving sports performance [27]. In a study isometric exercises are more effective than isotonic regimens in reducing shoulder pain and improving function in athletes [15].

The short intervention period (4 weeks) and lack of kinematic analysis of bowling mechanics are limitations.

CONCLUSION

The isometric exercises are highly effective for managing shoulder pain and improving functional capacity in bowlers, particularly in reducing disability and enhancing sports-specific performance over time. These findings suggest that IME should be considered a primary rehabilitation approach for bowlers with shoulder dysfunction, particularly for those aiming for long-term improvements in pain management and functional recovery.

DECLARATIONS & STATEMENTS

Author's Contribution

SA, RM and RU: substantial contributions to the conception and design of the study.
SR, UU, OF and MKUR: acquisition of data for the study.
UU, OF and MKUR: analysis of the data for the study.
SA and UU: interpretation of data for the study.
SA and RM: drafted the work.
SA, UU, RM, OF, RU and MKUR: revised it critically for important intellectual content.
SA, UU, RM, OF, RU and MKUR: final approval of the version to be published and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors contributed to the article and approved the submitted version.

Ethical Statement

A study was carried out at the City Cricket Club in Rawalpindi, Pakistan (CCC/July/24-01). The study was approved by the research and ethical committee (REC) of the Faculty of Rehabilitation and Allied Health Sciences (Ref# Riphah/RCRAHS-ISB/REC/MS-PT/01834) Riphah International University.

Consent Statement

Written Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments

None to declare.

Conflicts of Interest

None to declare.

Funding

None to declare.

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Research Article

Effectiveness of segmental stabilization and general lumber stabilization exercises in chronic low back pain: A randomized controlled trial

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Abstract:

Background: Chronic low back pain (CLBP) is a prevalent musculoskeletal condition that significantly impacts functional ability and quality of life. Exercise-based interventions are essential in managing CLBP by improving spinal stability and reducing pain. Segmental stabilization exercises (SSE) target deep stabilizing muscles, aiming to enhance motor control and reduce spinal micro-instability, whereas general lumbar stabilization (GLS) exercises focus on overall core muscle activation to improve spinal support.

Objective: to determine the effectiveness of segmental stabilization exercises and general stabilization exercises in chronic low back pain patients.

Methodology: A randomized controlled trial was conducted on n=44 participants with chronic low back pain patients at Isra University, Islamabad, and Benazir Bhutto Hospital, Rawalpindi, from January 2020 – August 2020. The participants were recruited through a non-probability convenient sampling technique and divided into two groups, n=22 participants in each group. The experimental group received Segmental Stabilization Exercises (SSE) while the control group received General Lumbar Stabilization (GLS). Visual Analogue Scale (VAS) was used to determine the severity or level of pain, a goniometer was used to measure the Range of Motion (ROM), Oswestry Disability Scale (ODI), was used to determine the severity or level of disability. The Friedman test with Wilcoxon was used within the group analysis whereas the Mann-Whitney U test was used for between the groups analysis.

Results: Both interventions SSE and GLS, significantly reduced ($p<0.05$) pain intensity and physical disability on ODI and its domains over time by the end of 4th week. Meanwhile, the between-group analysis revealed no statistically significant differences ($p\geq0.05$).

Conclusion: SSE and GLSE significantly improve pain and disability scores over four weeks. However, the lack of significant between-group differences suggests that both interventions have comparable efficacy.

Keywords: disability; functional disability; physical therapy; low back pain; segmental stabilization exercises; lumbar stabilization exercises; physical therapy.

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INTRODUCTION

Chronic low back pain (CLBP) is usually defined as pain in the back that persists for 7 to 12 weeks [1, 2]. It escalates linearly after 30 years of age until the 6th decade of life [3] and is more common in females compared to males [4]. CLBP is a restrictive condition may lead to a massive global burden that due to long absences from work and substantial workers' reimbursement and social security expenses due to work absences and retirement [5,6].

Though there are a lot of reasons leading to low back pain in many chronic cases, the cause is not known [7]. Postural issues, decrease in physical exercise, genetic issues, low levels of education along nutritional deficiencies are noteworthy risk factors of LBP [2]. Bodily workload escalates the risk of back ache [4]. Also, weakness of superficial abdominal and trunk muscles, and lack of control of deep trunk muscles, such as transversus abdominis (TrA) and lumbar multifidus (LM) is an important risk factor and strengthening of these muscles significantly improved CLBP and disability. CLBP patients usually reported delayed contractions of TrA [8].

Multi-disciplinary approach including pharmacological, surgical, and physical therapy is used to treat CLBP [9]. Exercise is a widely prescribed treatment, and it leads to improvement in function and work [10]. An intensive exercise program leads to the enhancement of bodily functions and has modest effects in the case of CLBP [9]. Furthermore, segmental stabilization exercises (SSE), [8] and general lumbar stabilization exercises (GLS) [11] are used to treat CLBP. Stabilization exercises improve neuromuscular control, strength, and endurance of muscles [11] while SSE also improves the timely activation of TrA and LM muscles [8]. These factors are central to the maintenance of dynamic trunk and spinal stability. Stabilization exercises are usually recommended for their safety and cost-effectiveness [11].

Although previous studies have investigated the effects of SSE and GLS in managing CLBP, limited research has examined their comparative effectiveness in a combined clinical and home-based setting with a follow-up beyond the supervised intervention phase. Most existing studies assess short-term outcomes within clinical settings, failing to determine whether improvements are sustained once patients transition to self-managed care. This study aims to address these gaps by comparing the effectiveness of SSE and GLS in CLBP rehabilitation, incorporating both supervised and home-based exercise phases, and assessing outcomes over four weeks.

METHODOLOGY

Design & Setting: A randomized control trial was conducted at the physical therapy department of Isra Institute of Rehabilitation Sciences (IIRS), Isra University Islamabad Campus. was after the approval of the Advanced Studies and Research Committee (IIRS/ASRC/OPT-008) of Isra University, Islamabad. The study was conducted from March 2019 – June 2022.

Selection criteria: The inclusion criteria for the recruitment in the study were males and females, between 15 to 60 years of age, and had chronic low back pain. While patient excluded with a history of back surgery, pregnancy, sciatica, any nerve root entrapment, vertebral bone fracture, stroke, spinal cord injury, intellectual disability, and rheumatologic disorders.

Sample Size: This sample size was n=44, calculated using a moderate effect size (f=0.35), with 80% power at a 5% significance level. A total of 60 subjects were evaluated for the study, out of which n=16 subjects were excluded for not meeting the inclusion criteria and unwillingness to participate in the study. The remaining n=44 participants were recruited through a non-probability convenient sampling technique and randomly divided into Segmental Stabilization Exercises (SSE) group (n=22), and Generalized Lumber Stabilization exercises (GLS) group (n=22) as shown in Figure 1.

Randomization & Blinding: The computerized randomization method by an independent researcher not involved in the assessment and management of the participant was used in this study. The allocation to the SSE group and the GLS group was through opaque sealed envelopes, which were opened only after participant enrolment. The blinding was not done as the individuals actively engaged in their assigned exercise interventions. To reduce performance bias, exercise logs of the home base plan were recorded in writing. Additionally, therapist blinding was not feasible since different exercise protocols were administered and remained a limitation, so follow the structured intervention protocols.

Intervention: The participants of the Segmental Stabilization exercise (SSE) performed a protocol, while the participants of the Generalized Lumbar Stabilization Exercises (GLS) group performed open and closed chain exercises. A detailed protocol is shown in Table 1. Each participant received a total of 3 sessions in a week, and the home care plan was guided by the treating physiotherapist. Each session lasted for 45 minutes and started in prone lying received 10 minutes of hot pack and TENS for two weeks. After two weeks, a Self-Monitored

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Home Exercise Plan of the Same Exercises was performed till 4th week. (table 1)

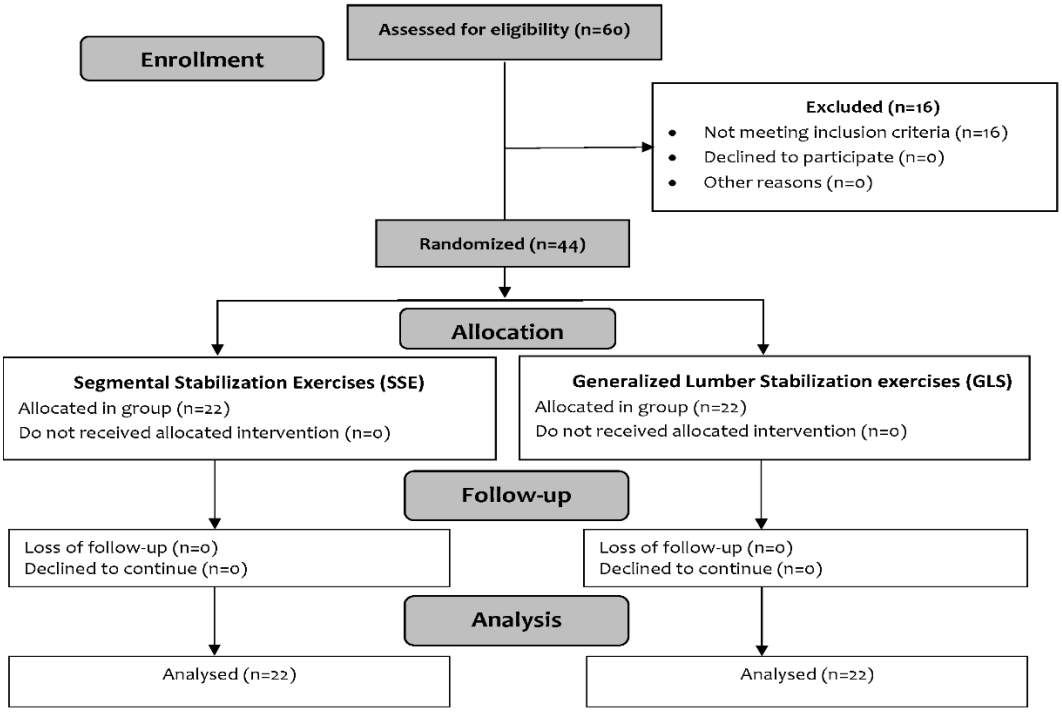

Figure 1: Consort diagram

Table 1: Intervention protocol segmental stabilization and generalized lumbar stabilization exercise plan

Week	Day	Segmental Stabilization Exercises (SSE)	Generalized Lumbar Stabilization Exercises (GLS)
Week 1	Day 1	*Abdominal Hollowing*: Activate deep core by drawing belly inward while lying. (3 sets×10 reps) *Pelvic Tilts*: Lie on back, tilt pelvis posteriorly (3 sets×12 reps) Transversus Abdominis Activation: Supine, draw navel towards spine. Hold 5 secs (10 reps)	*Pelvic Bridges:* Lie supine, lift hips keeping spine neutral (3 sets×12 reps) *Cat-Cow Stretch:* Spinal flexion/extension in quadruped (3 sets×15 reps) Bird Dog: Extend opposite arm and leg, hold 5 secs (10 reps)
	Day 3	*Quadruped Arm & Leg Raises*: Extend one arm/leg while maintaining lumbar stability (3 sets×10 reps) *Dead Bug:* Opposite arm and leg extend while keeping core engaged (3 sets×12 reps)	*Side Plank:* Hold for 15–30 secs each side (3 reps) *Seated Pelvic Clocks:* Rotate pelvis clockwise and counterclockwise (2 mins)
	Day 5	*Supine Marching:* Lie on back, engage core, lift legs alternately (3 sets×10 reps) *Knee Folds:* Slowly drop one knee outwards while keeping spine neutral (3 sets×12 reps)	*Hip Flexor Stretch:* Hold for 20 secs each side (3 reps) *Lying Trunk Rotations:* Knees bent, gently rotate side to side (3 sets×12 reps)
Week 2	Day 8	*Plank with Leg Lift:* Hold plank, lift leg alternately (3 sets×10 reps) *Resisted Side-Stepping with Band:* Walk sideways with resistance band (3 sets×15 steps)	*Superman Exercise:* Lift arms and legs while lying prone (3 sets×12 reps) Wall Sit: Hold for 30 secs, progress to 45 secs (3 reps)
	Day 10	*Side-Lying Leg Raises:* Engage core, lift top leg up and down (3 sets×12 reps) *Standing Pallof Press:* Hold resistance band at chest, press forward (3 sets×12 reps)	*Glute Bridges with Marching:* Perform bridge, then lift one leg (3 sets×10 reps) Knee-to-Chest Stretch: Hold 20 secs each side (3 reps)
	Day 12	*Standing Hip Hinge:* Hinge at hips while keeping back neutral (3 sets×12 reps) *Lunges with Rotation:* Lunge forward and rotate trunk (3 sets×10 reps)	*Standing Side Bends:* Slowly bend side to side (3 sets×15 reps) *Clamshells:* Lie on side, knees bent, lift top knee (3 sets×12 reps)
Week 3 & 4	Day 15-26	Self-Monitored Home Exercise Plan - Same Exercises	

Data collection procedure: The general demographics data such as age, gender, BMI, level of physical activity, and occupation were collected at baseline. Physical activity was measured through the International Physical Activity Questionnaire Short Form -7 (IPAQ SF-7), which is a valid and reliable tool [13]. Visual Analogue Scale (VAS) was used to determine the severity or level of pain. The VAS is a valid and reliable tool [12] and consists of ten characteristics which include 0= no pain and 10= severe pain. The Range of Motion (ROM) of lumbar flexion, extension, lateral right-side flexion, and lateral left-side flexion. The ROM was measured

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through a goniometer, which is a valid and reliable tool [14]. Oswestry Disability Scale (ODI) was used to determine the severity or level of disability and is a valid and reliable tool [15]. In ODI, 0 indicates no disability whereas 50 indicates severe disability.

Statistical Analysis: The descriptive statistics, mean, standard deviation, frequency, and percentages. As the VAS and total score of ODI were not normally distributed on The Shapiro–Wilk test and ODI's domains were in ordinal scale. The non-parametric test was used for data analysis. Therefore, the Mann-Whitney U test was used between the group analyses whereas the Friedman test with the Wilcoxon test was used within the group analysis. To determine the effectiveness of treatment protocols, the level of significance was set at $p<0.05$, and SPSS 21 was used to analyze the data.

RESULTS

The mean age of participants was 44.04 ±10.52 years. The mean height was 1.615±0.06 m, while the mean weight was 70.52±12.02 kg. The combined mean BMI was 26.89±4.29kg/m2. These values represent the overall characteristics of the study participants across both experimental (SSE) and control (GLS) groups.

Table 2: Within group changes Pain (VAS) and Disability (ODI)

		SSE (n=22)					GLSE (n=22)				
		M	*IQR*	*MR*	*Z/$\chi^2_{(3)}$*	*p-value*	*M*	*IQR*	*MR*	*Z/$\chi^2_{(3)}$*	*p-value*
VAS	Pre	9	1	4.00	-4.23	[a]0.00***	8	2	4.00	-4.0	[a]0.00***
	After 2 Weeks	2	2	2.83	-3.38	[b]0.00***	3	2	2.81	-3.00	[b]0.003**
	After 3 Weeks	2	3	1.80	-2.32	[c]0.02*	2	2	1.93	-3.41	[c]0.001**
	After 4 Weeks	1	2	1.37	61.07	[d]0.00***	1	2	1.26	55.63	[d]0.00***
Pain Intensity	Pre	4	1	4.00	-4.29	[a]0.00***	4	1	4.00	-4.16	[a]0.00***
	After 2 Weeks	1	1	2.52	-3.94	[b]0.00***	1	1	2.71	-3.16	[b]0.02*
	After 3 Weeks	1	1	1.89	-1.34	[c]0.180	1	1	1.81	-2.33	[c]0.02*
	After 4 Weeks	0	1	1.54	62.51	[d]0.00***	0	1	1.48	54.06	[d]0.00***
Personal Care	Pre	3	2	4	-4.26	[a]0.00***	3	2	4	-4.09	[a]0.00***
	After 2 Weeks	1	2	2.52	-3.16	[b]0.002	1	0.5	2.29	-1.66	[b]0.09
	After 3 Weeks	0	1	1.89	-1.89	[c]0.05	1	1	1.95	-1.73	[c]0.08
	After 4 Weeks	0	1	1.59	59.59	[d]0.00***	0	1	1.76	52.93	[d]0.00***
Lifting	Pre	4	1	4.00	-4.29	[a]0.00***	3	1	3.98	-4.00	[a]0.00***
	After 2 Weeks	1	1	2.65	-3.74	[b]0.00***	1	1	2.55	-2.49	[b]0.01*
	After 3 Weeks	1	1	1.76	-1.34	[c]0.18	1	2	1.93	-2.44	[c]0.01*
	After 4 Weeks	1	1	1.59	61.02	[d]0.00***	1	1	1.55	52.53	[d]0.00***
Walking	Pre	3	0	4.00	-4.34	[a]0.00***	3	0.5	4.00	-4.24	[a]0.00***
	After 2 Weeks	1	1	2.41	-3.0	[b]0.003	1	0.5	2.33	-1.41	[b]0.15
	After 3 Weeks	1	1	1.85	-1	[c]0.317	1	1.5	2.05	-2.44	[c]0.01*
	After 4 Weeks	1	1	1.74	60.19	[d]0.00***	1	1	1.62	53.22	[do].00***
Sitting	Pre	3	2	4.00	-4.25	[a]0.00***	3	2	4.00	-4.07	[a]0.00***
	After 2 Weeks	1	0	2.39	-2.82	[b]0.005**	1	1	2.21	-0.90	[b]0.36
	After 3 Weeks	1	1	1.89	-1.13	[c]0.25	1	1.5	2.05	-2.12	[c]0.03*
	After 4 Weeks	0	1	1.72	58.85	[d]0.00***	1	1	1.74	53.20	[d]0.00***
Sex Life	Pre	0	1	2.85	-2.04	[a]0.04*	0	0	2.57	-1.0	[a]0.31
	After 2 Weeks	0	0	2.46	-1.00	[b]0.31	0	0	2.48	0.00	[b]1
	After 3 Weeks	0	0	2.37	-.57	[c]0.56	0	0	2.48	0.00	[c] 1
	After 4 Weeks	0	0	2.33	12.85	[d]0.01*	0	0	2.48	3	[d]0.36
Standing	Pre	4	1	4.00	-4.26	[a]0.00***	4	1	4.00	-4.07	[a]0.00***
	After 2 Weeks	1	2	2.35	-2.64	[b]0.008*	1	1	2.19	-1.13	[b]0.25
	After 3 Weeks	1	2	1.93	-1.63	[c]0.10	1	1.5	2.00	-1.34	[c]0.18
	After 4 Weeks	1	1	1.72	59.84	[d]0.00***	1	0.5	1.81	52.79	[d]0.00***
Social Life	Pre	3	0	4.00	-4.29	[a]0.00***	3	1	4.00	-4.19	[a]0.00***
	After 2 Weeks	1	2	2.43	-2.53	[b]0.01*	1	0	2.40	-1.38	[b]0.166
	After 3 Weeks	1	1	2.00	-2.18	[c]0.02*	1	1	2.00	-2.44	[c]0.01*
	After 4 Weeks	0	1	1.57	59.23	[d]0.00***	0	1	1.60	52.10	[d]0.00***
Sleeping	Pre	3	2	4.00	-4.16	[a]0.00***	3	2	3.98	-4	[a]0.00***
	After 2 Weeks	1	1	2.45	-2.88	[b]0.004**	1	1	2.29	-.9	[b]0.36
	After 3 Weeks	0	1	1.89	-1.71	[c]0.08	0.5	1	2.10	-2.53	[c]0.01*
	After 4 Weeks	0	1	1.66	56.98	[d]0.00***	0	13	1.64	51.65	[d]0.00***
Traveling	Pre	3	1	4.00	-4.29	[a]0.00***	4	1	4.00	-4.08	[a]0.00***
	After 2 Weeks	1	0	2.54	-3.35	[b]0.001**	1	0	2.60	-2.67	[b]0.008**
	After 3 Weeks	0.5	1	1.78	-0.756	[c]0.45	1	1.5	1.93	-2.64	[c]0.008**
	After 4 Weeks	0	1	1.67	60.48	[d]0.00***	0	1	1.48	53.71	[d]0.00***
ODI Total	Pre	60	16	4.00	-4.20	[a]0.00***	62	21	4.00	-4.01	[a]0.00***
	After 2 Weeks	20	20	2.98	-4.21	[b]0.00***	18	10	2.81	-2.59	[b]0.009***
	After 3 Weeks	14	18	1.80	-2.8	[c]0.005**	14	18	2.00	-2.8	[c]0.00***
	After 4 Weeks	6	16	1.22	65.87	[d]0.00***	10	10	1.19	55.36	[d]0.00***

[a]Pre-after 2 weeks, [b]from 2 weeks – after 3 weeks, [c]from 3 weeks – after 4 weeks, [d]Pre- after 4 week
*Statistical significance-*p<0.05, **p<0.01, ***p<0.001; M-Median: IQR-Interquartile Range; MR-Mean Rank; ODI-Oswestry disability index; VAS-Visual Analogue Scale*

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Within-group analysis, using the Friedman test with Wilcoxon signed rank test for pairwise comparison, showed that both interventions Segmental Stabilization Exercises (SSE) and Generalized Lumbar Stabilization Exercises (GLS), significantly reduced ($p<0.05$) pain intensity as well as physical disability on ODI and its domains over time by the end of 4th week.

Between-group analysis using the Mann-Whitney U test revealed no statistically significant differences ($p\geq0.05$) in VAS and ODI domains between SSE and GLSE at any time point (table 3).

Table 3: Between group differences (Mann Whitney U Test)

	Variable	M	IQR	MR	M	IQR	MR	U-Stats	p-value
VAS	Pre	9	1	23.93	8	2	20.93	208.5	0.414
	After 2 Weeks	2	2	21	3	2	24.14	207.0	0.406
	After 3 Weeks	2	3	21.72	2	2	23.36	223.5	0.664
	After 4 Weeks	1	2	22.80	1	2	22.17	234.50	0.861
Pain Intensity	Pre	4	1	23.61	4	1	21.29	216	0.505
	After 2 Weeks	1	1	22.48	1	1	22.52	241	0.99
	After 3 Weeks	1	1	21.39	1	1	23.71	216	0.49
	After 4 Weeks	0	1	22.50	0	1	22.50	241.5	1
Personal Care	Pre	3	2	21.98	3	2	23.07	229.5	0.769
	After 2 Weeks	1	2	23.11	1	0.5	21.83	227.6	0.716
	After 3 Weeks	0	1	21.54	1	1	23.55	219.5	0.56
	After 4 Weeks	0	1	20.93	0	1	24.21	205.5	0.319
Lifting	Pre	4	1	23.80	3	1	21.07	211.5	0.438
	After 2 Weeks	1	1	21.87	1	1	23.19	227	0.707
	After 3 Weeks	1	1	19.91	1	2	25.33	182	0.13
	After 4 Weeks	1	1	20.76	1	1	24.40	201.5	0.290
Walking	Pre	3	0	21.96	3	0.5	23.10	229	0.727
	After 2 Weeks	1	1	22.63	1	0.5	22.36	238.5	0.936
	After 3 Weeks	1	1	20.83	1	1.5	24.33	203	0.32
	After 4 Weeks	1	1	22.15	1	1	22.88	233.5	0.836
Sitting	Pre	3	2	22.89	3	2	22.07	232.5	0.825
	After 2 Weeks	1	0	23.54	1	1	21.36	217.5	0.528
	After 3 Weeks	1	1	21.70	1	1.5	23.38	223	0.63
	After 4 Weeks	0	1	22.24	1	1	22.79	235.5	0.875
Sex Life	Pre	0	1	24.70	0	0	20.10	191	0.062
	After 2 Weeks	0	0	23.87	0	0	21.00	210	0.179
	After 3 Weeks	0	0	23.85	0	0	21.02	210.5	0.18
	After 4 Weeks	0	0	22.96	0	0	22.00	231	0.572
Standing	Pre	4	1	20.89	4	1	24.26	204.5	0.334
	After 2 Weeks	1	2	22.07	1	1	22.98	231.5	0.802
	After 3 Weeks	1	2	21.04	1	1.5	24.10	208	0.40
	After 4 Weeks	1	1	20.61	1	0.5	24.57	198	0.268
Social Life	Pre	3	0	22.04	3	1	23.00	231	0.782
	After 2 Weeks	1	2	22.00	1	0	23.05	230	0.767
	After 3 Weeks	1	1	21.54	1	1	23.55	219.5	0.57
	After 4 Weeks	0	1	21.50	0	1	23.60	218.5	0.529
Sleeping	Pre	3	2	24.25	3	2	19.64	181.5	0.212
	After 2 Weeks	1	1	23.20	1	1	21.74	225.5	0.682
	After 3 Weeks	0	1	21.26	0.5	1	23.86	211	0.42
	After 4 Weeks	0	1	21.74	0	13	23.33	224	0.603
Traveling	Pre	3	1	21.70	4	1	23.38	223	0.645
	After 2 Weeks	1	0	21.43	1	0	23.67	217	0.485
	After 3 Weeks	0.5	1	26.26	1	1.5	23.86	213	0.46
	After 4 Weeks	0	1	22.80	0	1	22.17	234.5	0.850
ODI Total	Pre	60	16	22.67	62	21	22.31	237.5	0.925
	After 2 Weeks	20	20	22.67	18	10	22.31	237.5	0.925
	After 3 Weeks	14	18	21.28	14	18	23.83	213.5	0.5
	After 4 Weeks	6	16	21.43	10	10	23.67	217.0	0.561

*Statistical significance-*p<0.05, **p<0.01, ***p<0.001; M-Median: IQR-Interquartile Range; MR-Mean Rank; ODI-Oswestry disability index; VAS-Visual Analogue Scale*

DISCUSSION

The purpose of the study was to determine the effectiveness of segmental stabilization exercises and general lumbar stabilization exercises on pain and disability in patients with chronic low back pain with lower back pain over four weeks. It was hypothesized that SSE would be more effective as compared to GLS, however, based on the results hypothesis was rejected. The efficacy of stabilization exercises in improving core stability,

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decreasing pain, and improving functional outcomes.

The significant reduction in pain intensity, as measured by VAS, is supported by prior studies suggesting that lumbar stabilization exercises improve neuromuscular control, thereby decreasing pain perception [16, 17]. Furthermore, the observed decrease in Oswestry Disability Index (ODI) scores is consistent with findings from Mahmood et al. (2022), who reported substantial improvements in physical function following core stabilization training [18].

The results of the study showed significant improvement in pain, and disability after segmental stabilization exercises measured through VAS, and ODI which is supported by the previous studies, in which SSE significantly improved pain, and ROM and reduced functional disability [19-21]. The possible reason for the improvement is exercising TrA and LM, which improves muscle activation, and segmental protective function and reduces stress on the lumbar [8]. Thus, proper segmental stabilization exercises are effective in improving pain, ROM, and thus disability.

According to the result of the recent study pain, ROM, and disability were significantly improved after general stabilization exercise. The results of this study are in coherence with the previous literature, which reported significant improvement in pain, ROM, and disability after stabilization exercises [11]. The improvement that occurred may be due to the open-chain and closed-chain exercises, which strengthen the TrA and LM muscles. Therefore, stabilization exercises reduced pain and ROM and thus disability because of strengthening and activation of TrA and LM muscles [22]. In low back pain, the delayed contractions of the TrA muscle make the trunk unstable and lead to reduced postural and motor control and the working of spinal muscles. Also, closed-chain exercises, which are performed on unstable surfaces are more effective in improving postural balance [23].

Furthermore, no significant difference was observed between SSE and GLS in improving pain, ROM, and disability. The previous study supported the findings of the current study, which reported segmental stabilization exercises are equally effective to other physiotherapy treatments such as lumbar stabilization exercises [24]. The possible reason for the non-significant difference could be due to the techniques used. Both treatment procedure focuses on the activation of TvA and LM muscles [8, 23]. Also, stabilization exercises strengthen the superficial and deep muscles of the trunk and abdomen which provides stability and reduces the pain and thus disability [11]. The non-significant between-group differences may also suggest that SSE and GLSE may have similar therapeutic effects [25, 26].

The sample size of the current study was smaller due to time constraints, so this study lacks generalizability to a wider population.

CONCLUSION

Both SSE and GLSE significantly improve pain and disability scores over four weeks. However, the lack of significant between-group differences suggests that both interventions have comparable efficacy. The inclusion of a home-based follow-up phase stresses the practicality of self-managed care after supervised intervention, providing insights into the sustainability of improvements beyond clinical settings. Future studies should explore long-term effects and adherence strategies to optimize patient outcomes in self-managed rehabilitation programs.

DECLARATIONS & STATEMENTS

Author's Contribution

SMZ: substantial contributions to the conception and design of the study.
SMZ: acquisition of data for the study.
SMZ and FMZ: analysis of the data for the study.
AA, SMZ and MA: interpretation of data for the study.
AA, SMZ, MA, HA, and FMZ: drafted the work.
AA, SMZ, MA, HA, and FMZ: revised it critically for important intellectual content.
AA, SMZ, MA, HA, and FMZ: final approval of the version to be published and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors contributed to the article and approved the submitted version.

Ethical Statement

The study was conducted after the approval of the Advanced Studies and Research Committee IIRS/ASRC/OPT-008 of Isra University, Islamabad.

Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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Funding Sources

None to declare.

Conflicts of Interest

None to declare.

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Research Article

Effectiveness of kettle bell workout on abdominal muscles strength In recreational athletes: a randomized controlled trial

Ismat Ullah[1,7]*, Amna[2], Natasha Amjad[3], Naseer Ullah[4], Danish Rauf[5] , Liao Qin[6]

ABSTRACT

Background: Recreational athletes often lack access to specialized strength training as kettlebell workouts on abdominal muscle strength can provide valuable insights

Objective: to determine the effectiveness of a Kettlebell training program in improving abdominal muscle strength among recreational athletes.

Method: A RCT was conducted on n=40 recreational athletes without history of neuromuscular injury in the last six months. Participants were randomly assigned into two Experimental Group (n=20) engaged in kettlebell training and Control Group (n=20) maintained their usual routine without any structured fitness training Abdominal strength was measured before and after the 12-week period using a seven-stage abdominal muscle strength test. Data were analyzed using SPSS software.

Result: The mean age of 21.73±1.78 years and Body Mass Index (BMI) was 20.18±0.68 kg/m². The between-group comparison at post-test revealed a statistically significant difference (p=0.007), with a moderate effect size (r=0.425), indicating that the Kettlebell training had a meaningful impact on abdominal muscle strength.

Conclusion: The study indicates that Kettlebell training is an effective method for improving abdominal muscle strength.

Keywords: abdominal strength; core stability; Kettlebell training; recreational athletes.

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INTRODUCTION

Core strength is a fundamental component of physical fitness, athletic performance, and injury prevention. The abdominal muscles play a central role in core stability, contributing to posture maintenance, balance, force generation, and reducing the risk of musculoskeletal injuries[1]. Strengthening these muscles will enhance functional movement patterns and athletic capabilities[2].

Traditional core strengthening programs typically involve exercises such as sit-ups, planks, and resistance machine-based workouts, like crunches, leg raises, and planks are commonly prescribed to target the abdominal muscles[3]. A study highlights the effectiveness of isometric and dynamic core exercises in improving abdominal muscle endurance and strength. However, these exercises often focus on isolated muscle activation rather than functionally engaging multiple kinetic chains [4].

In recent years, strength training methodologies have evolved to emphasize dynamic and functional movements, with kettlebell training emerging as a popular modality due to its ability to engage multiple muscle groups simultaneously[5]. Kettlebell workouts incorporate ballistic and isometric movements that challenge core stability, coordination, and muscular endurance. Such as kettlebell swings, Turkish get-ups, and windmills are frequently incorporated into training routines for their perceived benefits in core activation, but their direct impact on abdominal muscle strength remains underexplored[6, 7].

Existing studies suggest that kettlebell training activates the posterior chain and core muscles due to the explosive hip hinge movement demonstrated that kettlebell training improved back and core endurance in working adults, implying potential benefits for abdominal strength[5, 8]. Similarly, it was found that kettlebell swings generate significant core activation due to the demands of trunk stabilization[9]. However, while these studies support the involvement of the core in kettlebell training, there is limited empirical evidence specifically assessing its effectiveness in strengthening the abdominal muscles compared to traditional core exercises[10].

Most previous research has focused on general fitness improvements, with an emphasis on core endurance rather than absolute strength measures. Furthermore, randomized controlled trials (RCTs) directly comparing kettlebell workouts with conventional abdominal strengthening exercises remain scarce. This study aims to bridge this gap by investigating the effects of a structured kettlebell training program on abdominal muscle strength in recreational athletes from various sports. By comparing the outcomes of kettlebell exercises with conventional core strengthening routines, this study will provide valuable insights for fitness professionals, athletes, and rehabilitation specialists seeking optimal strategies for abdominal strength development.

METHODOLOGY

Study Design and Setting: A parallel-group, pre-test, and post-test experimental design was implemented. The study was conducted at the I-8 Active Gym located in I-8 Markaz, Islamabad, Pakistan, for a duration of 12 weeks. Ethical approval was obtained from the Board of Studies, Project Evaluation Committee (PEC), Institutional Review Board (IRB # 905-IV-A), and the Board of Advanced Studies and Research (BASR) at the University of Lahore, Pakistan.

Participants: A total of n=40 healthy recreational athletes from various sports disciplines were recruited for this study. Eligibility criteria included individuals with no neuromuscular injury in the last six months. The participants having recent musculoskeletal injury or pain were excluded from the study.

Sample size: The required sample size per group, calculated using G*Power with an effect size of 0.8, an alpha level of 0.05, and a power of 0.86, is approximately n=20 participants per group. This results in a total sample size of n=40 participants for the study. The Participants were randomly assigned into two Experimental Groups (n=20) engaged in kettlebell training and the Control Group (n=20) maintained their usual routine without any structured fitness training. (Figure 1)

Randomization and blinding: Random allocation was performed using a computer-generated randomization sequence. Allocation concealment was maintained by employing sealed opaque envelopes. Due to the nature of the intervention, blinding of participants was not feasible. However, assessors responsible for outcome measurements were blinded to group allocations.

Intervention: The kettlebell training program was designed to follow a structured 12-week plan with a 1:2 work-to-rest ratio. Participants attended training sessions twice weekly, leading to a total of 24 sessions. Each session lasted approximately 45 ± 10 minutes. Each exercise lasted 25 seconds, followed by 50 seconds of rest. To allow for recovery between different exercises, a 2-minute break was provided when switching movements. The workout included five key kettlebell exercises: the kettlebell deadlift, two-handed kettlebell swing, kettlebell clean, one-arm kettlebell snatch, and front squat with a jump. Each exercise was performed for five sets, maintaining a consistent rhythm of work and rest. Participants started with a

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12 kg kettlebell for the first four weeks before progressing to an 18 kg kettlebell for the remaining eight weeks. This gradual increase in weight helped build strength and endurance over time. Throughout the program, the structure remained the same ensuring uniformity in sets, exercise duration, and rest periods, so participants could focus on steady improvement without unnecessary variation. The control group maintained their usual routine without any structured fitness training.

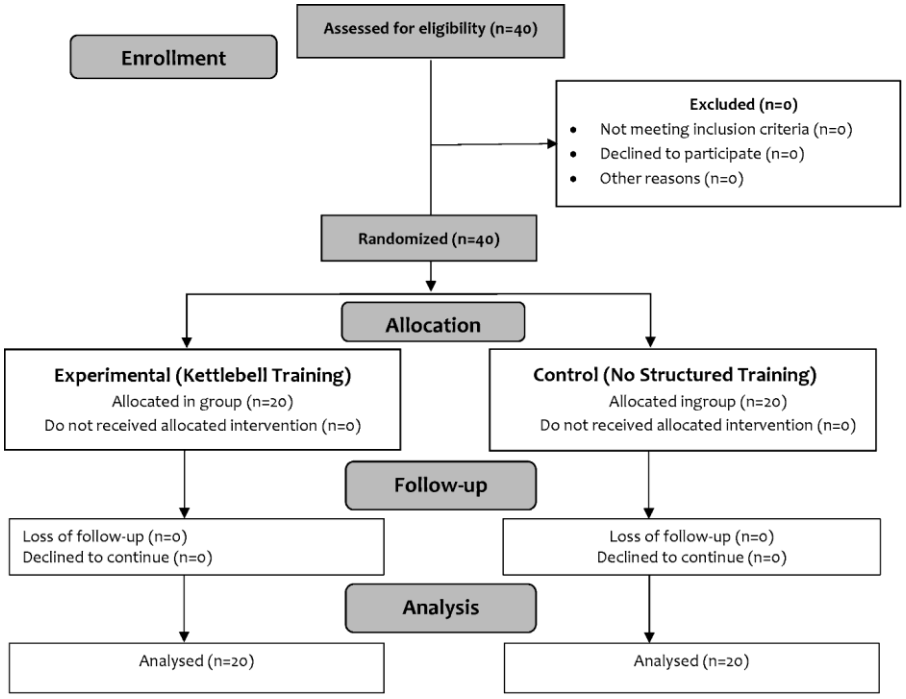

Figure 1: CONSORT diagram

Outcome Measures: The Seven-Stage Abdominal Strength Test is a standardized assessment used to evaluate abdominal muscle strength. It is a progressive test consisting of seven levels, each increasing in difficulty. All assessments were conducted one week before and one week after the intervention to ensure consistency.

Statistical Analysis: Data analysis was performed using SPSS software. Descriptive statistics (means and standard deviations) were used to summarize participant characteristics and outcomes. As the abdominal strength was measured on a 7-stages ordinal scale, a non-parametric, Mann Whitney U test was applied to see group differences, while Wilcoxon sign ranked test was applied for within-group analysis. The median, interquartile range, and mean rank were used as descriptive statistics. To determine the effect size correlation (r) was used, and the level of significance was set at $p<0.05$ using SPSS version 26.

RESULTS

The descriptive statistics for the participant (n=40) indicate that ages range from 19 -25 years, with a mean age of 21.73±1.78 years. The participant's Body Mass Index (BMI) varies between 18.55 and 21.65, with an average BMI of 20.18±0.68 kg/m².

At the pre-test score both groups were comparable at the baseline (p = 0.899), Th post-intervention, the Kettlebell group demonstrated an increase in abdominal muscle strength (M=3, IQR= 2.0-4.0, MR of 25.35), whereas the Control group had a median score of M=2, IQR=1.0-3.0) and a lower MR of 15.65. The between-group comparison at post-test revealed a statistically significant difference (p=0.007), with a moderate effect size (r=0.425), indicating that the Kettlebell training had a meaningful impact on abdominal muscle strength. Within-group analysis showed a significant improvement in the Kettlebell group from pre-post (p<0.001), whereas no significant (p=0.317) change was observed in the Control group. (table 1)

Table 1: Within-Between group analysis of abdominal muscle strength

	Kettlebell (n=20)			Control (n=20)				
	M	IQR	MR	M	IQR	MR	p-value	Effect Size (r)
Pre	2	1.0 - 3.0	20.73	3	2.0 - 4.0	20.28	0.899	-
Post	3	2.0 - 4.0	25.35	2	1.0 - 3.0	15.65	0.007**	0.425
MR	10.50		-	0		-	-	-
p-value	0.00***		-	0.317		-	-	-

Significance level- p<0.05, p<0.01** & p<0.001***; M-Median; IQR-Iter Quartile Range; MR-Mean Rank; r=Correlation*

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DISCUSSION

This study adds significant insight to the ongoing discussion around functional strength training by showing that kettlebell workouts can genuinely improve abdominal muscle strength in recreational athletes. The results revealed a statistically significant gain in abdominal strength in those who participated in the kettlebell training, with a moderate effect size (r=0.425), supporting the idea that this form of exercise has practical benefits for core development.

Unlike traditional core exercises that typically isolate muscle groups like crunches or planks, kettlebell movements are more dynamic. They involve multiple joints and planes of motion, which help to build trunk stability, coordination, and neuromuscular control[3, 11]. Exercises such as kettlebell swings cleans, and snatches incorporate explosive, full-body movements that actively challenge the core, making them particularly suitable for athletes involved in fast-paced, high-intensity sports[7].

While earlier research has acknowledged kettlebell training's role in enhancing overall core endurance and engaging the posterior chain, not many studies have specifically looked at its impact on abdominal strength using a randomized controlled approach [7, 12]. This study helps fill that gap by offering concrete evidence that kettlebell training, even over a relatively short period, can lead to measurable improvements in abdominal strength when compared to structured training. The use of the Seven-Stage Abdominal Strength Test, a reliable and progressive tool, further adds to the validity of these findings.

Our results, aligned with previous research, demonstrate the benefits of Kettlebell training on abdominal strength. Jay et al. (2013) reported significant improvements in abdominal strength and endurance following a six-week Kettlebell program, incorporating exercises such as swings, Turkish get-ups, and windmills[13]. Similarly, Wilson et al. (2015) found that Kettlebell exercises, including the snatch and windmill, activated core muscles more effectively than traditional exercises like crunches and planks[14]. Lake et al. (2017) observed enhanced abdominal strength and power in collegiate athletes after integrating Kettlebell training into their regimen[15]. While Layon et al (2017) highlighted the high levels of abdominal muscle activation during Kettlebell swings and cleans[16].

There are some limitations to consider. The study didn't compare kettlebell training with traditional core workouts like planks or sit-ups, so we can't say for sure whether it's more effective than those methods. Also, with only 40 participants and a 12-week timeframe, it's possible that longer-term effects or sport-specific adaptations weren't fully captured.

CONCLUSION

The study indicates that Kettlebell training is an effective method for improving abdominal muscle strength. It can recommend as a valuable component of strength and conditioning programs for individuals aiming to improve core stability and overall physical performance. Future research should explore gender-based variations to optimize its benefits further.

DECLARATIONS & STATEMENTS

Author's Contribution

The following format should be used for author's contribution.
IU and DR: substantial contributions to the conception and design of the study.
IU and A: acquisition of data for the study.
IU, NA and NU: interpretation of data for the study.
LQ: analysis of the data for the study.
IU and AS: drafted the work.
IU, A, NA, NU, DR and LQ: revised it critically for important intellectual content.
IU, A, NA, NU, DR and LQ: final approval of the version to be published and agreement to be accountable for all aspects. of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors contributed to the article and approved the submitted version.

Ethical Statement

The study was conducted after approval from Institutional Review Board (IRB # 905-IV-A) at the University of Lahore, Pakistan.

Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Further data can be available on request.

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We would like to acknowledge Mr Armaghan Khalid for facilitating the data collection at I-8 Active Gym Islamabad.

Conflicts of Interest

The authors declare no conflict of interest.

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The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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Research Article

Cross-cultural adaptation, reliability, validity and responsiveness of Urdu version of neck outcome score (NOOS)

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ABSTRACT

Background: Neck pain and associated disability significantly impact individuals' daily lives and well-being. Effective assessment and management of neck-related conditions require the use of standardized Outcome Measures. The Neck Outcome Score (NOOS) is a well-recognized tool designed to evaluate neck pain, in Urdu-speaking individuals is needed.

Objective: to cross-culturally adapt the NOOS into Urdu and evaluate its reliability, validity, and responsiveness.

Methods: Translation and cross-cultural adaptation of the Urdu version of NOOS were brought about and administered to n=200 patients and n=70 healthy participants. All participants were asked to fill out NOOS-U, Neck Disability Index-U, Visual Analog Scale pain, and VAS disability. For test-retest reliability, n=46 patients filled NOOS-U twice after 48 hours. Toward the end of 3 weeks, Patients were asked to fill out NOOS-U, Short Form-36, NDI-U, VAS scales, and the Global Rating of Change. NOOS-U was evaluated for Reliability, Validity, and Responsiveness

Results: NOOS-U exhibited good Test-Retest Reliability (ICC2,1=0.86-0.99) and Internal Consistency (Cronbach alpha=0.93). Construct validity results had satisfactory correlations of NOOS-U with NDI-U, SF-36, VAS pain, and VAS disability ($p<0.001$). In the analysis for discriminant validity, a notable difference in the total scores of NOOS-U between the patients and healthy participants was observed ($p<0.001$). Furthermore, the responsiveness of NOOS-U was statistically significant ($p<0.001$) among the improved and not improved group.

Conclusions: This study demonstrated that NOOS-U is a valid, reliable and responsive instrument for the assessment of nonspecific neck pain among patients who can understand Urdu.

Keywords: Neck pain; reliability; responsiveness; translation; validity.

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INTRODUCTION

Non-specific neck pain is defined as pain perceived in the cervical region whose origin and pathophysiological mechanism are unknown [1]. It has a high prevalence all around the world [2, 3]. In Pakistan, a 54% occurrence of neck pain was found over a 6-month period, with 37% of people reporting persistent symptoms [4]. It prevails in various vocational groups in Pakistan, ranging from 26.5% to 72% [5-7]. According to a study conducted in 2017, there is a high prevalence of non-specific neck pain especially in widowed or separated people with low income and low educational levels who perform their work in sitting or leaning postures throughout the day [8].

The cervical region being the most intricate articular system of the human body, has a complex arrangement of bones, muscles, nerves, discs, tendons, and ligaments that make it an important structure anatomically and physiologically where pain mostly presents along decreased muscle flexibility, strength, and decreased range of motion leading to functional limitations and disabilities at worst [8]. Other signs and symptoms include stiffness, headache, radiating pain, and numbness to name some.

Pain itself is subjective and therefore only the patient can truly rate and describe its characteristics including onset, intensity, location, duration, etc. Pain assessment is a multi-dimensional process crucial to tailor the treatment protocol [9]. Clinicians may use different self-report pain measures along with clinical tests, labs, and imaging to get firsthand information on the patient's condition. Many valid and reliable tools are widely used in practice. These include Visual Analog Scale-Pain [10], Visual Analog Scale-Disability [10], Neck Disability Index [11], Northwick Park Questionnaire [12], Neck OutcOme Score [13] etc.

The NOOS scale assesses the patients comprehensively with its 34 questions under 5 domains including mobility and stiffness, symptoms, sleep disturbance, everyday life and pain, participation in everyday life and Quality of Life (QoL). It incorporates a range of activities and situations a person may come across that exacerbate a person's neck pain in daily living [13].

Muslims may experience neck pain during prayers which were seemingly not addressed in scales like the Northwick pain scale and NDI. We can find questions regarding QoL in NOOS, particularly in its participation domain which is not observed in NDI. Such a wide array of questions like those in NOOS is always a better alternative than simpler tools with little expanse like NDI and much better than a single question tool such as numeric pain rating scale (NPRS), which leaves the examiner with very little understanding of the patient's condition [13, 14].

The NOOS questionnaire has been previously translated and validated into three languages: Turkish [15), Arabic [16] and Chinese [17]. As Urdu is one of the major languages spoken by millions of people in Pakistan, India, and other regions. However, a validated and culturally adapted Urdu version of the NOOS is not yet available for clinical and research use. The absence of a standardized Urdu version limits healthcare professionals from accurately assessing neck-related conditions in Urdu-speaking populations. The study aimed to cross-culturally adapt the NOOS into Urdu and evaluate its reliability, validity, and responsiveness.

METHODOLOGY

The study was conducted for the duration of 1 year, June 2022 to June 2023 after the approval from the ethics review committee of Margalla Institute of Health Sciences (MIHS) (ERC #. DN/149/22). The study was approved by the Declaration of Helsinki. The tool has been translated after obtaining permission through the concerned authorization via email.

The translation process followed the established guidelines of Beaton et al [18]. There were five steps in the process as follows;

Step 1 was the *Forward Translation* of the original document of Neck Outcome Score (NOOS)was independently forward translated conceptually by two translators fluent in both Urdu and English languages named T1 and T2. One translator was an Assistant Professor (M-Phil) from the linguistic department of a university and the other translator was a senior physiotherapy lecturer having master's degree in Musculoskeletal Physical Therapy. After translation, both translators provided the written reports.

Step 2 was the *Synthesis of* the combined version developed after evaluation and consensus on identifying and resolving the discrepancies to create a preliminary initial translation (PI-TL) of the instrument in Urdu.

Step 3 was *Back Translation* by the two self-employed professional translators having master's degree in linguistic without any medical background then back-translated the unified PI-TL version into the English language (BT1 and BT2), to accurately reflect the original meaning in Urdu. One translator was an Assistant Professor (M-Phil) from the Urdu department of a university and the other translator was a senior physiotherapy lecturer having master's degree in Musculoskeletal Physical Therapy. After translation both translators provided the written reports. Both translators were unaware of the explored concepts.

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Step 4 was the *Expert Review*, In which an expert committee reviewed all reports from steps 1-3 and evaluated for clarity of the instructions, items, and response format. Based on the initial steps and suggestions made by the expert committee, the translated tool was rendered in the pre-final instrument. The committee included methodologists, health professionals both Physical therapists and Dentists, language professionals, translators, and researchers. The expert committee ensured equivalence between the English and Urdu versions of the questionnaire.

Step 5 was the *Cognitive Debriefing* of the tool. The pre-final form of Neck Outcome Score-Urdu (NOOS-U) was administered to a sample of n=40 patients for face validity. All patients were subjected to a structured interview after completion of the NOOS-U. All subjects answered the questionnaire and were encouraged to point out any difficulties and necessary modifications are made based on patient feedback. Findings of the adaptation process were evaluated by the researchers and a final approved NOOS-U questionnaire was subjected to further psychometric testing.

Sample Size: a total of n=200 patients and 70 healthy participants were recruited in the study in accordance with international guidelines for psychometric testing [19].

Instruments: The *NOOS-U* was administered in the study which comprises 34 questions as discussed above. The standardized Likert scale options are given as answers with a minimum score of 0 to a maximum score of 4. The scores calculations were done as; Subscale Score= (100-Mean Score of the Subscale) ×100)/4. Thus, a higher score indicates better functioning, while a lowers indicates poor [25]. It takes on average 10-15 minutes to complete the questionnaire. Subjective pain and disability were measured by *VAS pain and VAS disability* respectively. Both have been proven to be valid and reliable tools time and again by numerous research [10]. Both these tools have a scale of 0 to 10 on a 100-mm horizontal line denoting no pain/restriction at all at "0" to the worst pain/restriction imaginable at a score of "10". The quality of life was assessed using a well-researched self-reported measure called *Short Form-36* Health Survey. This measure consists of 36 questions that cover 8 domains of health [20]. Available in multiple languages, SF-36 has proven to be a valid, reliable, and responsive measure [21]. *Neck Disability Index (NDI-U)* was also used which is a valid and reliable (ICC=0.99) tool widely used in clinical settings. It consists of 10 items, each scored from 0 (no disability) to 5 (complete disability) which adds up to a total score of 50 [22]. The *Global Rating of Change (GROC) scale* is a 15-point scale used to evaluate a patient's self-perception of pain deterioration or improvement over time. Patients were requested to rate the general condition of their neck from 7 ("a very much worse") to +7 ("very much better") since the start of treatment. The scale is easy to administer, has good reproducibility, requires minimal skills, and is also sensitive(sensitivity=0.83-0.93) to change [23].

Participants: The individuals between the ages of 18 and 65 years, irrespective of their gender and suffering from non-specific neck pain, were part of the research study. Moreover, the participants of the study required sufficient literacy skills to read Urdu language. The participants without any history of neck pain and/or pathologies or injuries were recruited in the healthy group of the study. Patients with a history of neck fracture or surgery in the last 3 months, neurological deficits, tumors, rheumatological diseases, or infections. Furthermore, diagnosed psychiatric disorders patients were also excluded from the study.

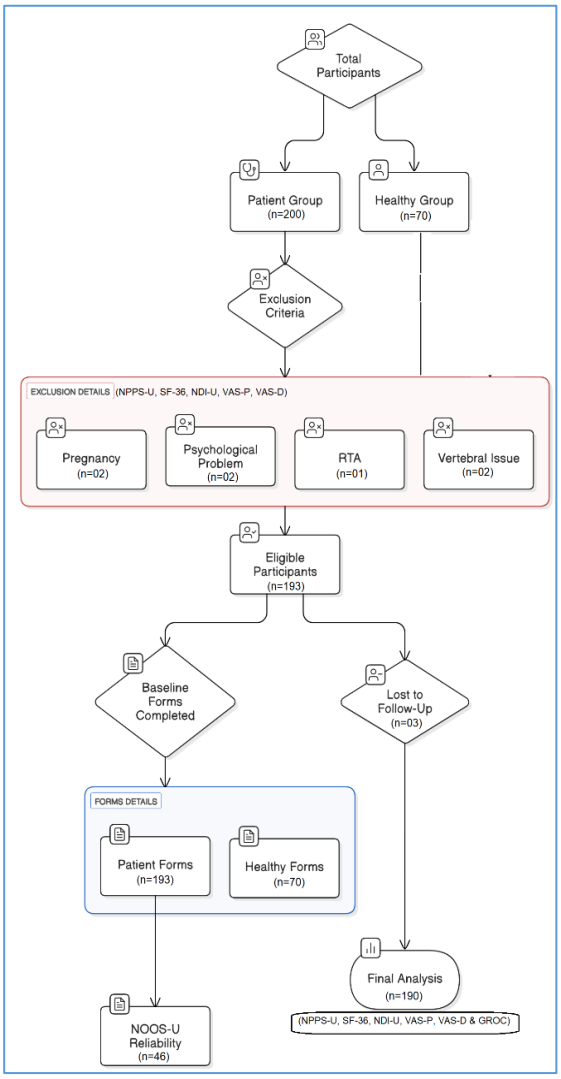

Figure 1: Study flow chart

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Data collection procedure: Self-structured questionnaire was used for demographic data and disease-related questions. Patients and healthy participants were required to fill NOOS-U, SF-36, NDI-U, VAS pain, and VAS disability. From the patient's group, n=46 randomly nominated people were asked to fill out NOOS-U after a 48-hrs interval. After 3 weeks during which the patients received standard physiotherapy and/or allopathic (comprising mainly of electrotherapy, cervical stretching, hot pack, and NSAIDs) treatment, NOOS-U, SF-36, NDI-U, VAS pain, VAS disability and the GROC scale were again administered as post-treatment assessment. All patients and healthy participants provided written informed consent.

Data analysis: All statistical analyses were conducted using the Statistical Package for the Social Sciences version 26 software. The reliability of NOOS-U was established by test-retest reliability and internal consistency. To conduct test-retest reliability, n=46 randomly selected people completed the NOOS-U twice with a 48 hrs interval. A good reliable tool should have an ICC value of ≥ 0.80 [24]. Internal consistency was measured by the value of Cronbach's Alpha. A value of +0.80 or greater is good internal consistency [25]. Content validity observes the completeness of item responses, and the distribution of scores and assesses magnitudes of floor and ceiling effects. Floor and ceiling effects were to be considered if more than 15% of the respondents reached the lowest or highest possible score, respectively. Discriminant validity was gauged by calculating the differences in the total score of NOOS-U between the patient (n=190) and healthy group (n=70) using an independent t-test. To test construct validity, analysis was performed through correlation among NOOS- U and SF-36, NDI-U, VAS pain, and VAS disability [25]. The global rating of change (GROC) scale dichotomized the patients into improved and not improved groups. Responsiveness was analyzed by comparing the change scores between improved and not improved groups, through Pearson's correlation.

RESULTS

Translation and cross-cultural adaptation was done under the guidelines of Beaton et al[18]. There were no additional problems found throughout the translation, review, or pilot-testing processes. The results of the pilot testing phase revealed no differences in terminology or meaning in the translated version of the NOOS-U. Participants did not ask for help understanding the questionnaire or any of its items. As a result, no changes were made to this version. Hence, the final version of NOOS-U was administered to the sample for Psychometric Testing. The table 1 displays demographics and clinical characteristics of both groups.

Table 1: Demographic characteristics of patient (n=193) and healthy (n=70) group

Variables		Patient Group M±SD/n(%)	Healthy Participants M±SD/n(%)
Age (Years)		34.85±11.75	26.44±8.27
Gender	Female	104(53.9)	47(67.1)
	Male	89(46.1)	23(32.9)
BMI		25.03±5.03	23.71±5.28
Duration Of Neck Pain In Months		11.24±14.82	NA
Work Status	Employed	127(65.8)	45(64.3)
	Un-Employed	66(34.2)	25(35.7)
Education	Matric	17(8.8)	1(1.4)
	Intermediate	21(10.9)	4(5.7)
	Undergraduate	45(23.3)	31(44.3)
	Graduate	110(57.0)	34(48.6)
VAS		-	-
Pain	-	5.12±1.33	NA
Disability		5.02±1.28	NA
Noos-U		-	-
Mobility		58.93±16.85	100±0.00
Symptoms	-	50.87±15.33	95.79±7.25
Sleep		64.54±22.59	100±0.00
Activity		59.04±13.54	100±0.00
Participation		65.54±19.08	100±0.00
SF-36		-	-
Physical Functioning		59.17±16.32	95.71±6.32
Role Physical		55.18±37.75	95.7±15.33
Bodily Pain		40.23±13.41	79.13±12.54
General Health	-	69.24±17.04	82.33±11.86
Vitality		54.66±16.12	72.07±13.77
Social Functioning		64.77±18.72	89.28±14.94
Role Emotional		38.17±35.99	84.29±29.88
Mental Health		67.19±14.78	79.31±12.69

BMI-Body Mass Index; M-Mean; SD-Standard Deviation; SF- Short Form; VAS-Visual Analogue Scale

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For content validity, all the participants completed the questionnaires with no missing items. Furthermore, No floor or ceiling effect was observed for any domain or the total score of NOOS-U. For construct validity, the domains of NOOS-U had a weak to moderate correlation ($p<0.05$) with VAS pain and VAS disability as observed in Table 3. All the domains of NOOS-U had moderate correlations with NDI-U whereas NOOS-U and SF-36 had a weak to moderate correlation among related domains.

Regarding the Internal consistency and test-retest reliability of the NOOS-U, most domains, including mobility, sleep, and participation, showed excellent (ICC>0.95) reliability. The symptoms and activity were slightly lower but still good reliability. Cronbach's Alpha values were exceptionally high (≥0.93), indicating strong coherence of items within each domain. Furthermore, minimal changes in mean scores between measurements suggest no significant practice effect or measurement drift. (table 2)

For Discriminant validity, a significant difference in the total score of NOOS-U was found between patients and healthy participants with a $p<0.001$ as the healthy group had better scores falling towards the higher limits while the patient group had scores closer to the lower limits.

A total of n=190 patients were evaluated for responsiveness. The results exhibited a significant difference ($p<0.05$) in NOOS-U change scores between the two groups, with the improved group having a higher change score than the stable (not improved) group. (table 4).

The mean and SD for the change score NDI-U were 5.80±4.95, for the change score VAS pain were 2.72±1.35, for the change score VAS disability were 3.87±1.63, and for the change score Bodily pain was 23.42±17.62. (table 5)

Table 2: Test-retest reliability of all domains of NOOS-U

NOOS-U	1st Measurement M±SD	2nd Measurement M±SD	Cronbach's α	ICC Value	CI (95%)
Mobility	58.93±16.85	60.02±17.34	0.98	0.97	0.95-0.98
Symptoms	50.87±15.33	50.11±17.49	0.96	0.93	0.88-0.94
Sleep	64.54±22.59	64.40±22.36	0.99	0.99	0.99-0.99
Activity	59.04±13.54	59.99±15.40	0.93	0.86	0.76-0.92
Participation	65.54±19.08	66.41±19.41	0.99	0.99	0.98-0.99

CI-Confidence Interval; ICC-Intraclass correlation; NOOS-Neck OutcOme Score; M-Mean; SD-Standard Deviation

Table 3: Correlation between NOOS-U, Vas Pain, Vas Disability, NDI-U, bodily pain (SF-36), physical functioning (SF-36)

	NOOS-U				
	Mobility (r)	Symptoms (r)	Sleep (r)	Activity (r)	Participation (r)
VAS pain	-0.59***	-0.4**	-0.39**	-0.49***	-0.34**
VAS disability	-0.4**	-0.33**	-0.29*	-0.59***	-0.43***
NDI-U	-0.58***	-0.46***	-0.59***	-0.57***	-0.65***
Bodily Pain (SF-36)	0.56***	0.37***	0.37**	0.53***	0.37**
Physical functioning (SF-36)	0.54***	0.33**	0.47***	0.67***	0.49***

*Significance level: p<0.001***, p<0.01** & p<0.05**

Table 4: Responsiveness between improved and not improved group

NOOS-U Domains	Improved Group (Mean ± SD)	Not Improved Group (Mean ± SD)	Mean Difference	p-value
Mobility	19.22 ± 11.24	10.95 ± 11.24	8.27	0.001**
Symptoms	17.22 ± 14.97	4.67 ± 18.66	12.55	0.001**
Sleep	14.88 ± 15.19	7.92 ± 10.75	6.96	0.00***
Activity	18.24 ± 13.66	6.25 ± 13.00	11.99	0.001**
Participation	13.36 ± 13.99	4.33 ± 19.22	9.03	0.00***

*Significance level: p<0.001***, p<0.01** & p<0.05**

Table 5: Change scores correlations between NOOS-U, SF-36, NDI-U, VAS pain, and VAS disability

	NOOS-U				
	Mobility (r)	Symptoms (r)	Sleep (r)	Activity (r)	Participation (r)
Bodily pain (SF-36)	0.36**	0.25**	0.22**	0.43***	0.16
Physical functioning (SF-36)	0.25**	0.15*	0.15*	0.25**	0.25**
VAS pain	0.45***	0.37***	0.31**	0.43***	0.28**
VAS disability	0.26**	0.33**	0.16*	0.32**	0.18*
NDI-U	0.47***	0.52***	0.54***	0.49***	0.58***

*Significance level: p<0.001***, p<0.01** & p<0.05**

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DISCUSSION

The main objective of the study was to translate and cross-culturally validate the original version of NOOS into Urdu language, followed by its psychometric testing. To the best of our knowledge, this study was the fourth to translate and validate NOOS after Chinese, Turkish, and Arabic ever since its development in 2015. No changes were made during the adaptation and translation process of the questionnaire. This study included n=193 patients and 70 healthy participants where the female population outnumbered the male population, making it a female-dominant study. In the original study, the Turkish and the Chinese study were female-dominant as well. The Arabic study however was a male-dominant study [15-17, 26].

The mean age of the participants in our study was 34.85±11.75 years in the patient group (table 1). In the Turkish study, the mean age was 35.88 ± 13.79 years, the original study had 47.8 ± 13.7 years, the Arabic study had 42.19 ± 2.91 years, and the Chinese version had a mean age of 48.9 years. The difference in mean age especially with the Chinese version is that they only included patients who needed cervical disc surgery, for which the average age is 35 to 55 years [27].

The study findings demonstrated that NOOS-U had good reliability, internal consistency, and responsiveness. The values for internal consistency for all domains of NOOS-U were greater than 0.90 proving good internal consistency. This observation is analogous to the previously reported results of NOOS-Tr (≥0.80) and NOOS-C (0.89). NOOS-Ar had a value > 0.89 with the lowest value in subscale 'sleep' IC=0.89 and the highest in the subscale of participation i.e., IC=0.96. The original study had the Cronbach alpha value of 0.85-0.92 with the exception of subscale symptoms (0.77) [15-17]. The test-retest reliability results represented strong consistency with previous studies. The ICC values for NOOS-U, NOOS-TR, NOOS-Original, and NOOS-AR showed high reliability across all domains, with NOOS-AR demonstrating the highest values (≥0.98) in mobility, symptoms, sleep, activity, and participation. NOOS-U also showed excellent reliability, particularly in mobility (0.97), sleep (0.99). and participation (0.99).

Regarding the construct validity, the domains of NOOS-U had a weak to moderate correlation ($p<0.001$) with VAS pain and VAS disability. All the domains of NOOS-U had moderate correlations with NDI-U ($r=0.45-0.65$, $p<0.001$), well backed up by the findings of NOOS-TR that also had moderate correlations with the related subscales of NDI [15]. The original study displayed a moderate correlation between NOOS and NDI as well (r=0.25-0.54). The Chinese version of NOOS and NDI-C had shown a strong correlation (r=-0.872, P=0.001) [17]. NOOS-U and SF-36 had a weak to moderate correlation among related, consistent with the results of the original study and NOOS-TR, both of which had displayed moderate correlations with SF-36 [13,15]. There were no floor or ceiling effects in any domains or the total scores of NOOS-U demonstrating excellent content validity, as observed in other versions [15-17,26].

The change scores of NOOS-U had demonstrated a moderate correlation with the change scores of NDI-U. The change scores of NOOS-U had a weak to moderate correlation with the change scores of SF-36 and change scores of the VAS pain scale, however, there was a weak correlation with the change scores of VAS disability. Thus, NOOS-U has shown significant results in terms of change scores ($p<0.001$). None of the other studies had analysed for change scores. The change scores of NOOS-U were statistically significant ($p<0.001$) among the improved and not improved groups, thus indicating that NOOS-U can detect differences between different stages of outcomes. This is uniform with the findings of NOOS-C ($p<0.001$) and the difference in the improved and not improved groups of the NOOS-Original study [17,26].

The strength of the study is that all the analysis has been carried out following the international guidelines, including sample size determination. This study is the first to translate NOOS into Urdu language and test for its psychometric properties, enabling the Urdu-speaking population to use NOOS-U in clinical and research settings around the globe. However, the study solely focused on non-specific neck pain and it remains ambiguous whether these outcomes can be generalized to patients with neck pain originating due to other aetiologies.

CONCLUSION

This study demonstrates that NOOS-U is a valid, reliable and a responsive tool for the assessment of non-specific neck pain among patients who can understand Urdu language.

DECLARATIONS & STATEMENTS

Author's Contribution

MNF and SN: substantial contributions to the conception and design of the study.
AI, HN, and KSA: acquisition of data for the study.
AI, HN and KSA: interpretation of data for the study.
SN, AI, HN, KSA: analysis of the data for the study.
AI: drafted the work.
AI and SN: revised it critically for important intellectual content.
MNF, SN, AI, HN, KSA: final approval of the version to be published and agreement to be accountable for all aspects.

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of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors contributed to the article and approved the submitted version.

Ethical Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Research Ethical committee of Margalla Institute of Health Sciences (ERC Ref no. DN/149/22)

Consent Statement

Written informed consent was obtained from all participants of the study.

Data Availability Statement

Due to privacy the data presented in this study are available upon request from the corresponding author, as they are not publicly accessible.

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Conflicts of Interest

The authors declare no conflict of interest.

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No funding was involved in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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