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Research Article

Effects of Selective Functional Movement Assessment on Pain, Dysfunction, and Muscle Strength in Patients with Superior Cross Syndrome: A Randomized Controlled Study

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Abstract

Context: This study explored the impact of two interventions, selective functional motor assessment and routine shoulder and neck exercise training, on pain, dysfunction, and muscle strength in patients with Upper Crossed Syndrome.

Design: This randomized controlled trial involved 39 patients aged 20-23 years with Upper Crossed Syndrome, randomly assigned to conventional therapy group (n=19) or SFMA group (n = 20).

Methods: The routine group underwent standard shoulder and neck exercise training, while the SFMA group underwent targeted training post-SFMA evaluation for a total of 6 weeks. VAS score, SFMA evaluation results, and Maximal Voluntary Isometric Contraction (MVIC) of the upper trapezius and cephalic clippers were assessed pre- and post-training.

Results: Post-intervention, all indicators improved in both groups, but significantly so in the SFMA group compared to the conventional group (| t | > 2.288, P <.001). The SFMA group demonstrated reduced pain (P <.001), while no significant improvement in pain was observed in the conventional group. Both groups exhibited increased upper trapezius strength, with the SFMA group experiencing a more substantial increase (P =.002). The head splint strength notably improved in the SFMA group (P <.001), but not in the conventional group. The FHA and FSA groups showed significant improvement, but the SFMA group was more pronounced (P <.001).

Conclusions: This study indicates that SFMA-guided targeted training can effectively alleviate symptoms of upper cross syndrome, enhance exercise capacity, and rectify abnormal exercise patterns post-targeted correction programs.

Keywords: Upper Crossed Syndrome; Selective functional action assessment; Shoulder and neck exercise training

Introduction

In 1988, Dr. Janda initiated the inquiry into Upper Crossed Syndrome (UCS). Apart from the recognized muscular imbalance manifestation, UCS is frequently associated with distinct postural modifications, encompassing head extension, cervical lordosis and thoracic kyphosis, pteroid shoulder blades, etc., which impose mechanical strain on the cervical spine, influencing not just the posture but also instigating stability or flexibility complications in adjoining joints like the shoulder blades, clavicle, humerus, and thoracic vertebrae over time. Current evaluations and interventions for UCS primarily concentrate on quantitative analysis of morphology and stretching and relaxation exercises, disregarding the holistic movement pattern. The immediate outcome is satisfactory, however, the enduring effect is challenging to sustain; while comprehensive intervention proves efficacious, it lacks a scientifically validated and practical training theory and guidance blueprint. The Selective

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Functional Movement Assessment (SFMA), an innovative diagnostic system devised by Gray Cook et al., hinges upon a refined appraisal of fundamental movement traits. Armed with these test outcomes, predictive functional anomalies of the painful related areas are capable of being pinpointed precisely [2]. Furthermore, the "4 × 4 principle" stipulated by SFMA serves as a Treatment Plan for evaluation outcomes, offering a refreshing outlook considering conventional evaluation methodologies. This research scrutinized the influence of routine shoulder and neck exercise training and SFMA, two distinctive treatment strategies, on university students afflicted with upper cross syndrome.

Methods

Study Design

This randomized trial examined the influence of regular shoulder and neck exercise and SFMA intervention on UCS patients. Approval was received from The Ethics Committee of Xi'an Institute of Physical Education (No. XAIPE2024016). All participants provided voluntary consent.

Randomization and Blinding

Participants were assigned to either the experimental group (SFMA) or control group (routine training) by independent researchers using Excel2019. All but the therapist remained blinded to group allocation. Baseline data were comparable between groups.

Sample Size

Sample size was calculated using G-power 3.1 software, setting $\alpha = 0.05$, $\beta = 0.2$ [4]. Considering attrition, the sample size was increased by 10%. A total of 39 participants were recruited, numbered sequentially, and randomized using Excel 2019. No significant baseline differences existed ($P > 0.05$).

Participants

Rehabilitation therapists reviewed and controlled inclusion and exclusion criteria.

Inclusion criteria: ① Age 18 to 26 years, female; ② Sedentary time ≥ 6 hours/day [3]; ③ No recent sports injury; ④ Symptoms limited to shoulder and neck, relieved during exercise.

Exclusion criteria: ① Undergone other treatments within 2 weeks; ② Motor or sensory disorders; ③ Neck pain secondary to other diseases (e.g., tumors, neurological diseases) with prior injury or surgery.

Withdrawal criteria: ① Voluntary withdrawal; ② Poor compliance.

Interventions

The two groups engaged in six-week intervention training. The experimental group implemented targeted treatment based on SFMA evaluation outcomes; the control group performed routine shoulder and neck exercise training.

SFMA Group

Treatment selection was determined by the SFMA evaluation, considering the patient's functional and pain levels. The advanced training followed an easy-to-difficult progression. The movements were derived from the experimental group's "Movement: Functional Movement Systems: Screening, Assessment, Corrective Strategies" and adhered to the following guidelines throughout the intervention:

Prioritized Treatment: ① Flexibility issues take precedence, stability issues follow. ② Thoracic spine flexibility issues precede shoulder flexibility issues. ③ Flexibility issues of mobile joints outweigh those of stable joints.

Scientific Treatment: Adhere to the SFMA treatment principle. For flexibility issues, perform self-stretching followed by the "4X4 matrix"; stability issues, practice directly using the "4X4 matrix": ① Non-weight-bearing positions, primarily prone and supine; ② Four-point position, i.e., four-point kneeling; ③ Knee kneeling; ④ Standing position, with four resistance levels: ① No resistance - assist, provide feedback during training; ② No resistance; ③ Resistance - assist; ④ Resistance movement. All treatments began at 2 × 1, progressing to 2 × 2 → 3 × 1 → 3 × 2 → 4 × 1 → 4 × 2 → 2 × 3 → 2 × 4 → 3 × 3 → 3 × 3 → 3 × 4 → 4 × 4. Exercise content should be challenging, but compensatory movements should not exceed the patient's capacity. If current difficulty cannot be met, step-down training is employed. All treatments occurred thrice weekly for six weeks.

Regular Training Group

The control group conducted three times/week, 30 minutes/session shoulder and neck exercise training. This included self-stretching, joint range of motion, strength strengthening exercises, thoracic spine extension, and rotation exercises.

Muscle Self-Stretching Training: Draw the upper trapezius, sternocleidomastoid muscle, and levator scapularis muscle in a seated position for 10 seconds on each side, repeating five times, and then perform contralateral exercises.

Joint Range of Motion Training: Neck flexion, extension, and rotation: Slowly move the head to the maximum angle for 5 seconds, 10 times in a row.

Shoulder flexion, extension, and loop: Slowly move the upper limbs to the maximum angle for 5 seconds, 10 times in a row.

Muscle Strength Strengthening Exercises: Deep cervical muscles: Hold the elastic band with both hands, bypass the back of the head and the side of the head and place it on the pillow, close the jaw, and resist the elastic band in the opposite direction for continuous isometric contraction for 20 seconds, a total of five groups.

External rotator: Hold the elastic belt with both hands, do the external rotation of the shoulder joint, the upper arm is close to the body, the elbow is bent 90°, and the forearm is opened outward for 5 seconds, 10 times/group, a total of five groups.

Middle and lower bundle of trapezius: prone position, arms in a Y, T shape, hands naturally clenched thumbs up, arms away from the bed for 5 seconds, 10 times/group, a total of five groups.

Rhomboid muscle: The subject is in a prone position, the arms are placed on the side of the body in a W shape, the shoulder blades are closed, and the arms are removed from the bed for 5 seconds, 10 times/group, a total of five groups.

Thoracic Spine Extension Training: Stand with forearms against the wall, nose tip close to the wall, and slowly bend your knees for 5 seconds, 10 times/set, five sets in total.

Thoracic Spine Rotation Training: Kneel on your hands and knees, then raise your head with one hand, and do the action of turning your body over. Each flip reaches the limit, inhale back to the neutral position, 10 times/side, one group on the left

Outcome Measures

VAS score

Subjects' quantifier their subjective discomfort between 0 and 10, with 0 signifying no pain, 1 to 3 indicating mild, 4 to 6 indicating moderate, and 7 to 10 signifying severe.

Maximal Voluntary Isometric Contraction (MVIC)

Maximal isometric muscle strength was quantified utilizing a wireless remote sensing surface electromyography apparatus (microFET3, USA). Prior to the test, the skin was cleansed with alcohol, and the electrodes were positioned along the muscle fibers at the distended part of the abdomen. The distance between the two electrodes was approximately 2-3 cm. Notably, the upper trapezius and cephalic clips on the left and right sides of the subjects were primarily measured. The electrodes of the upper trapezius were situated on the junction between the shoulder peak and the spinous process of the seventh cervical spine, 1/3 of the distance from the shoulder peak. The cephalic clips were affixed at 1-2 cm adjacent to C4-5. The subjects underwent three MVIC tests of the upper trapezius and cephalic clips for 6 seconds. Select the middle 2 seconds EMG signal to compute the MVIC, and derive the average value.

Test methodology of upper trapezius muscle: seated, body neutral, head turned to the contralateral side, resistance applied vertically down to the acromion, the subject striving to elevate the scapula.

Cephalus test methodology: Sitting, the body remains neutral, the resistance level is applied forward above the occipital trochanter. Subjects extend the neck to maximum effort.

SFMA

Within the SFMA evaluation: 10 movements, rotational tests, categorization tests for D and P, all assessments adhere to the SFMA testing principles: ① Refrain from performing any warm-up exercises; ② Register as D in uncertain scenarios; ③ Subjects must not wear footwear and socks; ④ Evaluation actions should be completed in one session, and repeated attempts are not permitted; ⑤ To enhance test efficiency, evaluators conduct action demonstrations initially, and subjects learn actions to test. Dysfunction evaluation outcomes are expressed as Stability and Motor Control Dysfunction (SMCD), Joint Movement Dysfunction (JMD), and Tissue Extension Dysfunction (TED).

Forward Head Angle (FHA), Forward Shoulder Angle (FSA)

In the standing position, the subject relaxed laterally in front of the posture assessment wall chart, visually exposed the skin of the neck and shoulders, and the Mark ball identified the subject's C7 spinous process and acromion, and the midpoint of the flat cervical spine was photographed and documented. Taking the C7 spinous process as the reference point, the vertical line was drawn downward, connecting the auricle and acromion respectively. The angle between the auricle to C7 connection and the vertical line was FHA; the angle between the acromion to C7 connection and the vertical line was FSA, utilizing ScreenProtractor software for angle analysis, capturing three times, and deriving the average value [5].

Recurrence Rate Comparison

The recurrence rate at 1-month post-treatment was compared between the two groups

Statistical Analysis

SPSS25.0 statistical software was utilized for data analytics. The measurement data conformed to the normal distribution, expressed as mean ± standard deviation. The paired sample t-test was employed for intra-group comparison, and the independent sample t-test was utilized for inter-group comparison. $P < 0.05$ denotes that the difference is statistically significant.

Outcomes

In this study, no significant differences were observed between groups in terms of age (P = .085), height (P = .521), weight (P = .0707), BMI (P = .964), and daily sitting time (P = .532) variables, See Table 1.

After the intervention, VAS was significantly reduced within the experimental group (P < .001), while no significant difference was found between the experimental groups (P = .41), See Table 2.

After the intervention, the MVIC of the upper trapezius and cleft muscles increased in both groups, and the experimental group was significantly higher than the control group (P = .002). See Table 3 and Table 4.

After training, the frequency of functional impairment in

Table 1: Comparison of baseline data between the two groups.

	Experimental group (n＝19)	Experimental group (n＝20)	t	p
Age	23.54±1.56	22.25±2.17	-1.791	0.085
Height	1.66±0.69	1.68±0.07	0.651	0.521
Weight	58.31±9.26	59.63±9.30	0.38	0.707
BMI	20.94±1.95	20.10±2.02	0.046	0.964
Daily sitting time	7.54±1.71	7.94±1.65	0.636	0.532

Table 2: Comparison of VAS scores between the two groups before and after training.

Group	Before the intervention	After the intervention	t	p
Experimental group	2.94±0.77	0.78±0.75	10.137	p＜0.001
Control group	2.94±0.85	2.69±0.80	2.236	0.41
t	0	-6.976		
p	1	p＜0.001		

Table 3: MVIC ratio of upper trapezius before and after intervention.

Group	Before the intervention	After the intervention	t	P
Experimental group	37.33±5.00	47.57±6.60	-10.497	0.002
Control group	36.70±5.00	36.91±5.00	-2.566	0.022
t	0.348	4.987		
p	0.731	p＜0.001		

Table 4: MVIC ratio of cleft muscles before and after intervention.

Group	Before the intervention	After the intervention	t	p
Experimental group	42.06±6.39	50.71±5.15	-10.752	p＜0.001
Control group	41.64±6.10	41.6±5.90	0.237	0.816
t	0.189	4.657		
p	0.185	p＜0.001		

Table 5: SFMA.

Project	Group	Frequency (times)		Percentage	
		Before	After	Before	After
Neck flexion flexibility and/or stability issues	Experimental group	13	4	81.3%	25%
	Control group	14	8	87%	50%
Neck extension flexibility and/or stability issues	Experimental group	8	0	50%	0%
	Control group	7	4	44%	25%
Neck rotation flexibility and/or stability issues	Experimental group	12	3	75%	18.8%
	Control group	13	6	81.3%	37.5%
Shoulder pattern flexibility and/or stability issues	Experimental group	12	4	75%	25%
	Control group	11	6	68.8%	37.5%
Thoracic spine rotational flexibility and/or stability issues	Experimental group	13	2	81.3%	12.5%
	Control group	14	8	87.5%	50%
Hip flexion problem	Experimental group	8	0	50%	0%
	Control group	7	5	43.8%	31.3%
Tight posterior thigh chain	Experimental group	5	0	31.3%	0%
	Control group	6	6	37.5%	37.5%
Spinal flexion flexibility and/or stability issues	Experimental group	11	2	68.8%	12.5%
	Control group	9	5	56.3%	31.3%
Spinal extension flexibility and/or stability issues	Experimental group	5	0	31.3%	0%
	Control group	4	3	25%	18.8%
Core stability issues	Experimental group	9	1	56.3%	6.25%
	Control group	11	8	68.8%	50%

Table 6: FHA ratio before and after intervention.

Group	Before the intervention	After the intervention	t	p
Experimental group	39.00±3.44	32.13±3.48	9.019	P＜0.001
Control group	39.47±6.47	36.47±4.57	3.277	0.005
t	0.252	-3.7		
p	0.803	0.005		

Table 7: FSA ratio before and after intervention.

Group	Before the intervention	After the intervention	t	p
Experimental group	44.07±4.91	35.80±4.25	10.237	P＜0.001
Control group	44.12±7.83	42.59±7.48	2.928	0.01
t	-0.022	-3.204		
p	0.983	0.004		

SFMA grading tests decreased compared with the previous ones. See Table 5.

After training, FHA and FSA in the experimental group decreased significantly ($P < 0.01$), and were significantly lower than those in the control group ($P < 0.05$). See Table 6 and Table 7.

Table 8: Recurrence rate.

Group	Number of recurrence cases	Recurrence rate/%
Experimental group	1	6.25
Control group	8	50

Follow-up was conducted two months after the intervention, and the recurrence rate of the two groups was lower than that of the control group ($P < 0.05$). See Table 8.

Discussion

SFMA evaluates body asymmetries, limitations, and weaknesses utilizing "regional interdependence".[6] This research affirms that 6 weeks of SFMA-based exercise can notably alleviate shoulder and neck pain, augment upper trapezius and clipper strength ($p < 0.001$), diminish dysfunction (D) and pain (P) on SFMA evaluations, as well as reduce recurrence rates.

In previous scholarly endeavors, the management of UCS has oriented towards reestablishing equilibrium amongst the cross muscles, such as stretching exercises, strengthening programs, myofascial manipulation, corrective gymnastics, acupuncture, etc., which have been demonstrated to possess clinical efficacy [7-9], but have not considered the overall movement pattern, the recurrence rate is elevated, and the effect is challenging to stabilize. Secondly, neck discomfort or dysfunction is merely a symptom. UCS is a cluster of symptoms, encompassing cephalic extension, anterior shoulder, thoracic kyphosis, pterygoid scapulae, scapular dynamic disorders, limited thoracic spine flexibility, etc. The fundamental cause is the imbalance of body posture, compensatory movement of other regions when executing an activity. Former examination methodologies are accustomed to concentrating on the pain and symptoms reported, and scrutinizing local anatomical structures may overlook the issues unveiled under the perspective of the model On the contrary, if you directly evaluate physical fitness and athletic performance, it will be overlooked that these movements are executed in basic motor patterns. Without basic motor evaluation, it is impossible to understand the correlation between dysfunction patterns and induced pain. SFMA also emphasizes on muscle activation, movement patterns, and posture across the body, and parses the D and P that emerge in ten movement patterns. The primary intention is to ascertain whether it is a stability or flexibility encumbrance. For instance, the superior cross syndrome from the perspective of SFMA - head extension and shoulder induction will result in a decline in the flexibility of the cervical and thoracic vertebrae. Persistent pain results from compensatory movement of the lumbar vertebrae during routine motions, and subsequently the pain of the lumbar vertebrae will influence the angle of the pelvis during walking. The functions of various parts of the body influence each other and are closely linked.

Results from Table 6 indicate that over 80% of individuals will exhibit flexion and rotation disorders in the neck and thoracic spine due to prolonged sitting, resulting from muscle crossing, fascial tension, and joint movement control instability. Furthermore, the scapular muscles play a crucial role in shoulder and neck stability and flexibility [10]. The variations in shoulder muscle length cause a significant reduction in humeral head-to-acromion distance during arm elevation, consequently disrupting shoulder blade coordination [11], 75% of subjects display bilateral shoulder functional restrictions and imbalance in shoulder internal rotation, extension, and adduction (predominantly on the right side). Post-intervention, shoulder and neck dysfunctions were significantly reduced. UCS is characterized by weakened deep cervical flexors, hindering head and cervical spine motor control, rectus capitus muscle activation deficiency [12], hyperextension of the upper cervical spine (C1-C3), and flexion of the lower cervical spine (C4-C7), leading to increased neck posterior load. At this point, neck pressure is 3.6 times that of the correct posture [13], potentially exacerbating postural dislocation, neck pain, fatigue, and chronic musculoskeletal diseases. Research indicates that shoulder blade stabilization exercises [14], thoracolumbar fasciolysis [15], cervical spine stability training and visual feedback [16], and deep cervical flexor strengthening can reduce forward lean and enhance cervical spine stability and posture maintenance [17]. Arshadi [18] administered an eight-week targeted training, emphasizing shoulder blade balance restoration, progressing from no load to increased repetitions, duration, and ROM. Despite these efforts, trapezius superior bundle strength remained unchanged. Interestingly, after six weeks of our intervention, upper trapezius and head clipper strength increased while shoulder and neck dysfunction frequency decreased significantly, consistent with SFMA evaluation results.

Within this investigation, through SMFA analysis, tailored training was implemented based on the evaluation outcomes. From a functional standpoint, the origin of discomfort in Superior Cross Syndrome was discerned from the perspective of motor output - the issue of information input and central integration, which introduced fresh concepts for UCS clinical diagnosis and treatment, to avoid being guided by the patient's pain symptoms, prematurely focusing on the local symptoms whilst overlooking the holistic. For diverse etiologies (SMCD, JMD, TED), pointed training methodologies were employed, and the primary therapeutic aim was to establish the accurate movement pattern. Contrasting the results of the two movement screening assessments, the dysfunction exhibited by the subjects within the experimental group was generally mitigated after the intervention, with the problem being fundamentally addressed, and superior short-term and long-term curative effects were achieved. Limitations of this study: The study did not employ imaging assessment to ascertain its effectiveness for cervical spine alignment. Further research is warranted to address these limitations and to investigate the relationship between subacromial space and UCS utilizing other imaging techniques.

Conclusion

In general, compared to posture correction alone, SFMA intervention demonstrated superior efficacy in treating UCS, with reduced recurrence and adaptability for diverse dysfunctions. Ongoing studies in large populations across varying age groups may enhance clinical utility.

Confirmed

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