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Comparing the effects of no intervention with therapeutic exercise, and exercise with additional Kinesio tape in patients with shoulder impingement syndrome. A three-arm randomized controlled trial

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Abstract

Objective: To investigate if adding Kinesio tape to therapeutic exercise is an effective treatment to improve clinical outcomes compared to therapeutic exercise alone and no intervention, in patients with shoulder impingement syndrome.

Design: Three-arm randomized controlled trial

Setting: Outpatient setting

Subjects: One hundred and twenty patients (mean (SD): age 37.8 (5.4)) with shoulder impingement syndrome.

Intervention: Patients were randomly assigned to eight-weeks therapeutic exercise alone, therapeutic exercise with Kinesio tape, and control group.

Main measures: Pain was measured with a numerical rating scale and disability and scapular kinematics were measured with a relative questionnaire and motion analysis software respectively, at baseline and after eight-weeks intervention.

Results: There was significant differences in therapeutic exercise with Kinesio tape group vs. therapeutic exercise alone and control group respectively for pain ($d = -0.34$, $P = 0.042$; and $d = -1.53$, $P = 0.001$), disability ($d = -0.46$, $P = 0.024$; and $d = -2.18$, $P = 0.001$), scapular upward rotation at sagittal plane ($d = 0.33$, $P = 0.033$; and $d = 0.68$, $P = 0.001$), scapular plane ($d = 0.18$, $P = 0.045$; and $d = 0.43$, $P = 0.001$), scapular tilt at sagittal plane ($d = 0.55$, $P = 0.043$; and d = 1.39, $P = 0.001$), and scapular plane ($d = 0.29$, $P = 0.034$; and $d = 0.58$, $P = 0.001$). Therapeutic exercise alone was superior over control group in all significant outcomes ($P < 0.05$).

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Conclusion: Although therapeutic exercises alone showed positive effect on clinical outcomes, adding Kinesio tape to therapeutic exercises had more significant effects with larger effect sizes. Adding Kinesio tape to therapeutic exercise may be of some assistance to clinicians in improving clinical outcomes in patients with shoulder impingement syndrome.

Keywords
Exercise therapy, kinematics, kinesio tape, shoulder impingement syndrome

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Introduction

Shoulder impingement syndrome accounted for 44% to 65% of all complaints of shoulder pain[1] that leads to a malalignment in scapular kinematics.[2,3] Any alteration in scapular kinematics is believed to contribute to developing pathologic shoulder conditions.[3] A meta-analysis identified altered scapular kinematics with more scapular internal rotation and less scapular upward rotation and posterior tilt during upper extremity elevation, in the patients with shoulder impingement syndrome.[3] Thus, optimal scapular motion seems to be important for proper shoulder function and treatment targets.

The aim of therapeutic exercise must be to restore normal scapular kinematics by improving the muscle activity, strength, flexibility, and balance in muscle force couples that control the scapular position and motion.[4] The focus of rehabilitation should be on motion awareness and strengthening of the scapular upward rotators and the rotator cuff muscles.[5] Although a recent systematic review reported an exercise therapy alone is beneficial in relieving pain and disability compared to no exercises, it failed to find any study with reliable evidence for the positive effect of exercise therapy alone on scapular kinematics in the shoulder impingement syndrome patients.[6]

Using Kinesio tape may be considered as an appropriate strategy along with exercise treatment of shoulder impingement syndrome in a clinical setting.[7–9] The effect of Kinesio tape as a single intervention on scapular kinematics, in previous studies, has not been fully confirmed.[10,11] Conversely, adding Kinesio tape to different interventions acted as an extrinsic feedback mechanism to improve posture, alter muscle activity, and improve muscle recruitment patterns.[9,12] Saracoglu et al.[13] in their systematic review about the use of Kinesio tape on shoulder impingement syndrome pointed out that it can be useful associated with exercises especially at the beginning of the treatment. The authors emphasized that the use of Kinesio tape as adjuvant therapy in the rehabilitation of patients remains a subject that needs further investigation.

Due to inconsistencies and lack of high-quality evidence, and the need for the studies with a larger sample size, we aimed to investigate if adding Kinesio tape to therapeutic exercise is an effective treatment to improve clinical outcomes in patients with shoulder impingement syndrome, compared to therapeutic exercise alone and a control group who received a treatment-guideline brochure. We hypothesized that adding Kinesio tape to therapeutic exercise might enhance treatment effects primarily on pain, and secondarily on disability and scapular kinematics.

Material and methods

This study was a three-arm single accessor blinded randomized controlled trial with a 1:1:1 ratio allocation carried out in the department of Kharazmi University, between November 2018 and April 2019, and prospectively registered at www.umin.ac.jp (UMIN000035348), registered date of 2018/11/23). The study was performed by the ethical standards in the World Medical Association Declaration of Helsinki. Ethical approval was obtained from the Ethical Committee of Kharazmi University (IR.KHU.REC.1398.011).

Patients were recruited by physical therapists via flyers displayed at physical therapy clinics to

receive physiotherapy treatment. All patients were informed of the nature of the study and those who agreed to participate signed an informed consent agreement. They also were free to leave the study at any time they prefer.

To be eligible to participate, patients should meet all the following criteria: (1) pain lasting > six weeks, (2) having painful arc during exertion of flexion and abduction, (3) positive Neer or Hawkins-Kenney tests,[14,15] (4) painful resisted external rotation, abduction or painful Jobe's test.[16] Exclusion criteria were (1) history of surgery, fracture, traumatic onset, the existence of massive rotator cuff tears, long head of biceps tendon tears, degenerative joint disorders at the shoulder complex,[17] (2) being pregnant, and (3) receiving steroid injections during the last six months before the study.[18]

A total of 120 participants including both males and females met the study criteria and were randomly assigned to therapeutic exercise alone ($n=40$), therapeutic exercise with Kinesio tape ($n=40$), and control group ($n=40$). Patients were randomized by the slot-drawing method to two experimental groups and a control group. The randomization sequence was not disclosed until participants had completed their baseline assessments. The allocation was by sealed opaque envelopes, patients were assigned to each group by a sealed envelope containing the name of one of the three groups.

The patients were assessed within a week before the intervention (baseline) and after an eight-week intervention (post-intervention) by a blind physical therapist with over five years of experience. The primary outcome was pain and secondary outcomes were disability and scapular kinematics (scapular internal rotation, upward rotation, and posterior tilt). Only the involved side of each participant was assessed for kinematics data (with no applied Kinesio tape). At baseline and post-intervention, all outcomes were collected at the laboratory of biomechanics at the university. The interventions were provided at the university health center by two licensed and Persian native speaker physical therapists (one for therapeutic exercise and one for Kinesio tape) with three average years of experience.

Pain intensity was measured using numerical rating scale (0–10), with 0 signifying no pain and 10 worst imaginable pain. The patients were asked to rate their current level of pain. This scale is a reliable and valid tool for evaluating self-reported pain.[19]

The Iranian version of the Disabilities of the Arm, Shoulder, and Hand questionnaire was used to assess the disability of the upper limbs.[20] Scores range from 0 to 100, with higher scores indicating a worse condition. This version of the questionnaire is valid and reliable.[20] A decrease of 10-points on the questionnaire can be considered a clinically important improvement.[20]

Scapular kinematics were assessed using the 3-dimensional motion software (Innovative Sports Training, Inc, Chicago, IL) with the patients in a relaxed standing position in front of the transmitter.

Kinematic motion analysis consisted of selecting the scapular data of humero-thoracic elevation for both sagittal and scapular plane arm elevation. The planes were standardized using a flat surface to guide movement and ensure the proper plane of arm elevation.

During elevation, patients were instructed to keep their thumb pointing toward the ceiling, to slide their hand on the board, and to elevate their arm at a rate such that full elevation was accomplished over approximately 3 seconds. Three complete cycles of the movement were completed. Sensors were not removed or replaced between trials but were removed between the baseline and post-intervention measurement sessions. This procedure is reliable during elevation and lowering of the arm in asymptomatic individuals and patients with shoulder impingement syndrome based on Camargo et al.[21] Please see Supplemental Appendix 1 for detailed information about the scapular kinematics assessment.

The therapeutic exercise intervention was based on the study of Camargo et al.[21] The intervention was over eight weeks, three days a week, for one hour. This included three stretching and three strengthening exercises performed for either involved or uninvolved sides. Both experimental groups were similarly instructed and trained by a physical therapist. Both groups received the exercises on different days (even days for therapeutic

exercise group and odd days for therapeutic exercise with Kinesio tape group). Please see Supplemental Appendix 2 for detailed information about the therapeutic exercise intervention.

Kinesio tape was applied based on the study of Ozer et al.[11] The taping technique was to improve shoulder and scapular biomechanics during exercises. In the first session, the physical therapist explained the details about Kinesio tape (e.g., history, materials, different colors, and different usage based on the techniques) for patients in therapeutic exercise with Kinesio tape group. Also, patients were watched for any allergic reaction to the tape and no one had taping allergy. It took about five minutes to tape a participant for each session. Standard 5-cm Kinesio Tex (Kinesio tape-X050; Kinesio Tex, Tokyo, Japan) was used. Each session, Kinesio tape was removed before therapeutic exercise and applied again after therapeutic exercise for 24h. Please see Supplemental Appendix 3 for the fully instructed Kinesio tape technique.

To maximize the compliance in the treatment groups, besides being explained about the importance of the exercise intervention at the initial of each session, the patients were given a brochure of exercises accompanied by explaining how the program would positively affect the patients` symptoms and daily activities. Patients in both experimental groups received exercise intervention for eight weeks while those in therapeutic exercise with Kinesio tape group were given the tape as well.

Patients in the control group received no intervention; however, to consider the ethics of non-active management of the control group, patients were given a brochure about preventing overuse shoulder injuries and explaining how being active would relieve their symptoms. They were also encouraged to contact the team, in case of any problem or concern. In the case of pain, the control group was advised to use ice for about 20 minutes, three times a day,[22] or take a pain medication prescribed and guided by a physician.

The sample size calculation was considered a power calculation to detect between-group differences in the primary outcome measure (pain). Statistical power calculations were also based on a type I error probability level of alpha = 0.05, type II error probability level of beta = 0.20, a medium effect size of 0.25, and an anticipated dropout rate of 20%. Sample size calculations using G*Power software as by the previous studies 14 resulted in 99 patients (a 33-per arm of the trial), with a 15%–20% dropout-rate. Thus, a total sample size of 120 was required (40 patients per group).

Shapiro-Wilk and Levene tests were used to assess data distribution. One-way analysis of variance (ANOVA) was used to compare the group demographics and post hoc independent t-tests were performed in the case of a significant omnibus test. The dependent variables of interest were the kinematics, disability, and pain scores.

One-way analysis of covariance (ANCOVA), with a between-factor of the group (control, therapeutic exercise alone, or therapeutic exercise with Kinesio tape) and patients' baseline scores included as a covariate, was used to determine between-group differences. In the case of a significant omnibus test, pairwise comparisons were performed to examine potential between-group differences. 95% confidence intervals (CI95%) were calculated based on the adjusted group mean differences and effect sizes of the mean group differences were calculated as Cohen's D (0.2 = small effect, 0.5 = moderate effect, and 0.8 = large effect).[23] SPSS software version 22 with an alpha of 0.05 was used for statistical analysis.

Results

One hundred and fifty-seven were considered and 120 met the inclusion criteria of the study entered the study. Seven patients discontinued the treatment before post-testing due to personal reasons (three for the therapeutic exercise group and four for therapeutic exercise with Kinesio tape group) (Figure 1). There was a high degree of adherence to all three interventions (of the possible 24 sessions, therapeutic exercise alone group, 22 sessions, and therapeutic exercise with Kinesio tape group, 21 sessions). No adverse events were reported. Eleven patients (four females and seven males) in the control group reported that they used an ice pack between 1 and 2 days. No patients in the control

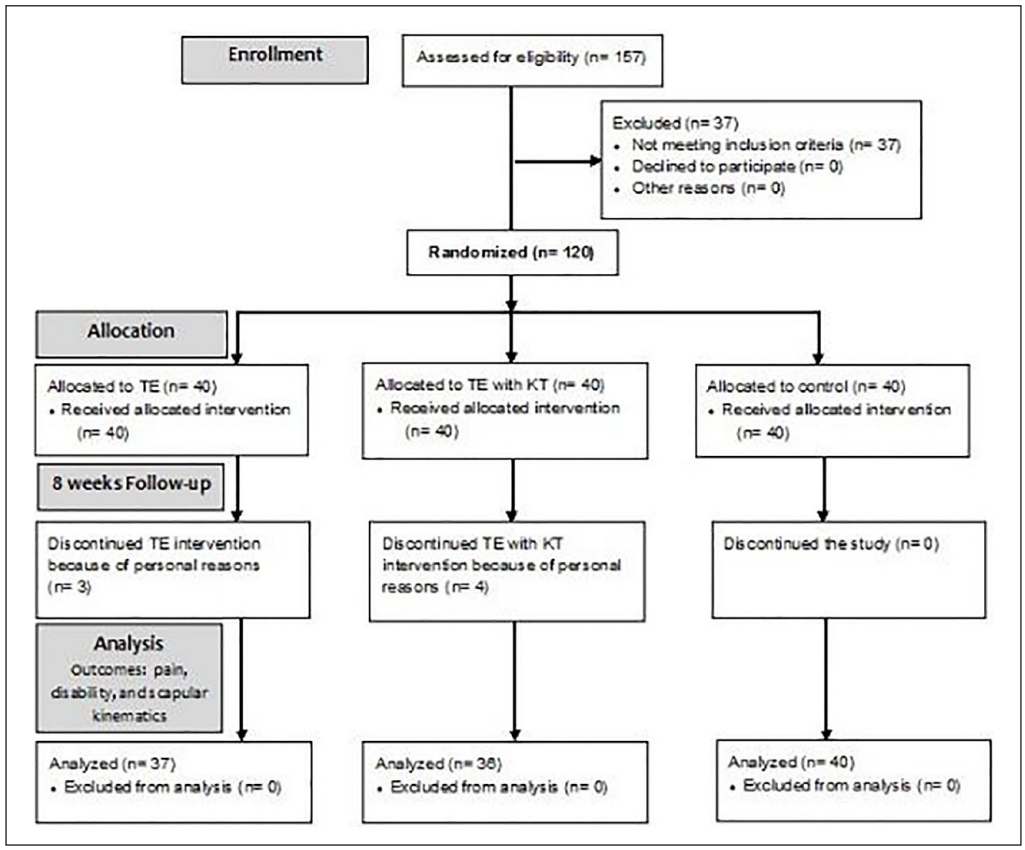

Figure 1. The CONSORT flow diagram.
TE with KT: therapeutic exercises with Kinesio tape; TE: therapeutic exercise alone.

group reported receiving medication during the study. There were no significant differences among the groups in demographic data (age, weigth, gender, arm dominance, and duration of sympthom; $P > 0.05$) (Table 1).

A significant treatment × time interaction effect was found for the **pain**, **disability**, **scapular upward rotation**, and **scapular tilt** ($P < 0.05$). No significant main time effects were found for scapular internal rotation ($P > 0.05$).

For all measured outcomes, the effects of both theraputic exercise alone and therapeutic exercise with Kinesio tape were significantly superior over the control group ($P < 0.05$). The therapeutic exercise with Kinesio tape group had better scores vs therapeutic exercise alone for **pain** ($P = 0.042$). Like pain, the therapeutic exercise with Kinesio tape group had better scores vs therapeutic exercise alone for **disability** ($P = 0.024$). The control group showed no significant changes for pain and disability ($P > 0.05$) (Table 2).

For kinematic outcomes, the control group showed no significant changes ($P > 0.05$). No significant differences were observed in both experimental groups for scapular internal rotation ($P > 0.05$) (Table 3). While, for **scapular upward rotation**, therapeutic exercise with Kinesio tape showed significant effect vs therapeutic exercise alone, at a sagittal plane ($P = 0.033$), and scapular plane ($P = 0.045$). The results weren't significant in therapeutic exercise for scapular upward rotation ($P > 0.05$) (Table 3). For **scapular tilt**, the therapeutic exercise with Kinesio tape group showed significant effect vs therapeutic exercise alone at

Table 1. Participants demographics and characteristics.

	TE with KT	TE	Control	*P* value
Age, years; mean (SD)	35.4 (4.4)	40.5 (5.5)	37.5 (6.3)	0.109
Weight, kg; mean (SD)	76.1 (5.3)	73.7 (7.2)	69.4 (8.1)	0.098
Gender – female; *n* (%)	20 (50)	22 (55)	21 (52.5)	0.522
Arm dominance – right; *n* (%)	11 (55)	12 (60)	12 (60)	0.528
Duration of symptoms; *n* (%)				
6–12 weeks	14 (35)	14 (35)	13 (32.5)	0.675
>12 weeks	26 (65)	26 (65)	27 (67.5)	0.648

SD: standard deviation; TE with KT: therapeutic exercises with Kinesio tape; TE: therapeutic exercise alone.

Table 2. Mixed within-between groups for the pain and disability outcomes assessed in the study.

Within-group						Between-groups	
Variable	Groups	Baseline mean (SD)	Post-intervention mean (SD)	Effect size and 95% CI (Lower limit–Upper limit)	*P*	Main effects with respect to time	*P*
Pain	TE with KT	6.2 (1.6)	3.1 (1.4)	2.06 (1.5 to 2.98)	0.001$^{\Phi}$	$F=4.26$; $P=0.023^{\Omega}$	0.001*
	TE	5.9 (1.3)	3.8 (2.5)	1.05 (0.87 to 1.43)	0.035$^{\Phi}$		0.004$^{¥}$
	Control	6.3 (1.9)	6.8 (2.8)	0.08 (–0.08 to 0.58)	0.416		0.042‡
Disability	TE with KT	25 (11.4)	11.7 (8.2)	1.33 (0.39 to 1.78)	0.001$^{\Phi}$	$F=7.43$; $P=0.011^{\Omega}$	0.001*
	TE	23.7 (7.8)	15.9 (9.8)	0.88 (0.34 to 1.15)	0.005$^{\Phi}$		0.011$^{¥}$
	Control	26.1 (3)	26.7 (5.2)	–0.14 (–0.7 to 0.07)	0.628		0.024‡

SD: standard deviation; TE with KT: therapeutic exercises with Kinesio taping; TE: therapeutic exercise alone; CI: confidence interval.
$^{\Phi}$Significant within-group changes.
*Significant between combined TE with KT and control groups.
$^{¥}$Significant between TE alone and control groups.
‡Significant between combined TE with KT and TE alone groups.
$^{\Omega}$Significant group × time interaction.

the sagittal plane ($P=0.043$), and scapular plane ($P=0.034$). Significant differences in therapeutic exercise alone in the sagittal plane ($P=0.001$) and scapular plane ($P=0.046$) were observed (Table 3).

Discussion

Our results showed that therapeutic exercise with Kinesio tape could have positive effects on pain and disability with higher within-group differences and larger effect size than therapeutic exercise alone and control groups. In addition, adding Kinesio tape to therapeutic exercise showed more significant effects than therapeutic exercise alone on scapular upward rotation and tilt in patients with shoulder impingement syndrome. These findings may indicate the potential benefits of adding Kinesio tape to therapeutic exercise to improve pain, disability, and scapular kinematics after eight-week intervention.

Adding an adjunct therapy to significantly enhance the effect of exercise therapy in patients with shoulder impingement syndrome is debatable. Camargo et al.[21] showed for pain, function, or scapular kinematics, the exercise-alone group demonstrated greater improvement than the exercise-plus–manual therapy group after four weeks of an intervention. However, Şimşek et al.[9] stated that Kinesio tape is effective in the rehabilitation of shoulder impingement syndrome when adding to a

Table 3. Mixed within-between groups for the kinematic outcomes assessed in the study.

Within-group						Between-groups	
Variable	Groups	Baseline mean (SD)	Post-intervention mean (SD)	Effect size and 95% CI (Lower limit–Upper limit)	*P*	Main effects with respect to time	*P*
Sagittal plane elevation							
Scapular internal rotation	TE with KT	47.9 (5.3)	46.8 (5.1)	0.21 (–0.65 to 0.2)	0.121	$F=0.32$; $P=0.432$	-
	TE	47.6 (6.3)	46.4 (8.3)	0.16 (–0.27 to 0.6)	0.136		
	Control	49.1 (5.8)	48.4 (5.4)	0.12 (–0.31 to 0.56)	0.426		
Scapular upward rotation	TE with KT	17.1 (10.8)	23.2 (9.9)	–0.58 (–1.03 to –0.1)	0.041$^{\Phi}$	$F=3.37$; $P=0.032^{\Omega}$	0.001*
	TE	16.6 (8.4)	19.6 (11.8)	–0.29 (–0.73 to 0.14)	0.076		0.021$^{¥}$
	Control	16.2 (14.9)	15.3 (13.0)	0.06 (–0.37 to 0.50)	0.126		0.033‡
Scapular tilt	TE with KT	–0.4 (1.7)	–4.5 (3.2)	1.6 (1.09 to 2.1)	0.001$^{\Phi}$	$F=2.53$; $P=0.043^{\Omega}$	0.001*
	TE	–0.5 (2.3)	–2.8 (2.9)	0.87 (0.41 to 1.33)	0.001$^{\Phi}$		0.025$^{¥}$
	Control	–0.6 (3.4)	–0.5 (2.5)	–0.03 (–0.47 to 0.4)	0.314		0.043‡
Scapular plane elevation							
Scapular internal rotation	TE with KT	35 (8.3)	33.1 (8.5)	0.22 (–0.21 to 0.66)	0.131	$F=0.43$; $P=0.215^{\Omega}$	-
	TE	38.0 (6.6)	36.6 (4.9)	0.24 (–0.19 to 0.68)	0.174		
	Control	35.9 (6.4)	36.5 (9.8)	–0.7 (–0.51 to 0.36)	0.366		
Scapular upward rotation	TE with KT	19.5 (13.5)	23.7 (8.8)	–0.46 (–0.81 to –0.1)	0.038$^{\Phi}$	$F=7.54$; $P=0.036^{\Omega}$	0.001*
	TE	20.6 (11.7)	22.1 (8.6)	–0.14 (–0.58 to 0.29)	0.106		0.045$^{¥}$
	Control	20.3 (13.2)	19 (12.5)	0.10 (–0.33 to 0.53)	0.111		0.045‡
Scapular tilt	TE with KT	–0.3 (1.1)	–2.2 (3.9)	0.66 (0.21 to 1.11)	0.001$^{\Phi}$	$F=2.66$; $P=0.041^{\Omega}$	0.001*
	TE	–0.5 (1.1)	–1.2 (2.7)	0.33 (0.10 to 0.78)	0.046$^{\Phi}$		0.042$^{¥}$
	Control	–0.5 (2.1)	–0.5 (1.3)	0.05 (–0.38 to 0.1)	0.211		0.034‡

SD: standard deviation; TE with KT: therapeutic exercises with Kinesio taping; TE: therapeutic exercise alone; CI: confidence interval.
$^{\Phi}$Significant within-group changes.
*Significant between combined TE with KT and control groups.
¥Significant between TE alone and control groups.
‡Significant between combined TE with KT and TE alone groups.
$^{\Omega}$Significant group × time interaction.

scapular stabilization and rotator cuff strengthening exercises.

How the Kinesio tape mechanism affects pain and function of the shoulder is still unclear. However, studies showed that Kinesio tape could affect symptoms in individuals with musculoskeletal pain and dysfunction through stimulating neuromuscular pathways to provide more proprioceptive feedback to realign the posture, attaching to the skin while providing assistance or limitation to the motion, and lifting soft tissue and fascia above the area of pain/ inflammation resulting in more microcirculatory flow beneath the skin.[8,24] Also, applied Kinesio tape may promote a greater proprioceptive effect, joint mechanical correction, and enhancement of muscle function.[25] Moreover, the three taping techniques that were applied in this study sought to provide facilitation of the lower trapezius muscle, inhibition of the upper trapezius muscles, and mechanical correction affecting the subacromial space.[25,26]

In the patients with shoulder impingement syndrome, a deficit in flexibility or strength in an agonistic muscle, which is compensated by the antagonist's muscle, may lead to a sub-acromial space reduction, a shoulder griddle dysfunction, and ultimately structural damage.[27] Kinesio tape might help the therapeutic exercise to increase the

subacromial space as well as to enhance the control of the muscles stabilizing the scapula throughout an arc of glenohumeral elevation motion resulting in modulating pain.[3]

Besides, the association of reducing pain with decreasing disability has been previously studied and moderate correlation has been reported.[28,29] Cook et al.[28] reported the correlation of pain intensity and disability in patients with shoulder dysfunction as 0.027 while, Anwer et al.[29] reported this correlation as 0.66. Although in the current study we did not analyze data correlation, we hypothesize that the significant reduction of pain in therapeutic exercise with Kinesio tape group could reduce disability outcomes.

The data of the present study could be found consistent with the study of Turgut et al.[18] on how to improve scapular kinematics through an exercise program. It seems to be effective on scapular kinematics a stretching and strengthening exercises should be combined with another adjuvant or exercise therapy.[18]

Kinesio taping could be applied as an effective adjuvant therapy to reduce the upper trapezius activity and to increase lower trapezius activity resulting in more scapular posterior tilt during functional activities.[30] Lower trapezius taping showed a significant increase in scapular posterior tilt in baseball players with shoulder impingement syndrome.[31]

Moreover, the relation between the shoulder proprioception and kinematic has been previously described.[31–33] Shih et al.[31] concluded that taping-associated immediate improvement in scapular reposition sense was accompanied by enhanced scapular kinematics including increased scapular posterior tilt and scapular upward rotation during arm elevation in the scapular plane. Although we did not assess shoulder proprioception in the current study, it can hypothetically be indicated that kinematic outcomes improvement in therapeutic exercise with Kinesio tape group might be partly due to enhanced joint proprioception in the direction of scapular tilt and upward/downward rotation.

The authors must acknowledge some limitations of the current study. First, as it is indicated in the method section the control group was advised to use ice or take a pain medication prescribed by a physician. This issue might affect the score of pain intensity in the control group; however, it did not seem ethical that because of data accuracy those in the control group tolerate pain. Second, we did not evaluate the long-term effect of the eight-week therapeutic exercise with Kinesio tape intervention. Although the eight-week therapeutic exercise with Kinesio tape intervention is shown as effective on symptoms in the patients with shoulder impingement syndrome, the results may not be transferred to a longer-term. Third, to minimize any placebo effect, we tried to reduce the length of time Kinesio tape was applied to. Due to the sliding nature of the scapula beneath the skin surface, there may be a limitation to interpret the results and the clinical value of the intervention. Although the study design allows for controlling non-specific effects of the intervention, adding a control group just applying Kinesio tape may be useful to control non-specific Kinesio tape effects. Fourth, although previous similar studies did not observe any considerable effect of placebo Kinesio tape,[11,33] we believe that the results of our study would be more reliable if we had another group that received a placebo Kinesio tape and we could observe how the placebo Kinesio tape can change the measured outcomes. Finally, it was not clear if patients' precision about pain and disability scores was affected by the length of time of Kinesio tape application and hands-on interaction in therapeutic exercise with the Kinesio tape group.

In summary, the findings of this study indicate adding Kinesio tape to therapeutic exercise provides more advantages to reduce pain and disability and improve shoulder kinematics in patients with shoulder impingement syndrome. Adding Kinesio tape to therapeutic exercise could clinically reduce pain and disability resulting in shoulder kinematics improvement. The authors suggest providing more studies with a long-term follow-up analysis and using placebo Kinesio tape intervention.

Clinical messages

- In patients with shoulder impingement syndrome exercise reduced pain and disability compared to not have the exercises
- Adding Kinesio tape to the therapeutic exercise program was associated with a significant increase in the beneficial effects on pain and disability

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Author contributions

A.L and P.R designed the experiments and drafted the manuscript. A.L assisted with the design of experiments and review of the manuscript. A.L, P.R, and S.K, and S.AP performed the experiments and analyzed the data. A.L and P.R authors discussed the results and commented on the manuscript.

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Supplemental material

Supplemental material for this article is available online.

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