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Original Article

Physiotherapy Section

Effectiveness of Ankle Stretching and Strengthening Exercises to Improve Rounded Shoulder Posture: A Pilot Study

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ABSTRACT

Introduction: Incorrect posture habits and reduced physical activity can predispose individuals to various changes in the muscular and skeletal structures. Rounded Shoulder Posture (RSP) is one such clinical manifestation that deforms the normal relationship of various structures. Different treatment protocols have been devised for correcting RSP; however, postural changes in the musculoskeletal system can also be addressed by focusing on muscular imbalances elsewhere in the biomechanical kinetic chain.

Aim: To analyse and investigate the efficacy of ankle muscle stretching and strengthening exercises in enhancing the correction of RSP in young adults.

Materials and Methods: The present pilot study was conducted at Amity Institute of Physiotherapy in Noida, Uttar Pradesh, and Prime Hospital and Ortho Centre in Faridabad, Haryana, India, from January 2021 to July 2021. A total of 30 young adults with RSP were randomly allocated into two groups of 15 each. Group 1 (control group) received six weeks of conventional exercises consisting of scapular stabilisation and stretching of the pectoralis minor muscle. Group 2 (experimental group) received ankle plantar flexor stretching and ankle dorsiflexor strengthening in addition to the conventional exercises, three times per week for six weeks, with each session lasting between 30 to 45 minutes. RSP and ankle Dorsi-Flexion (DF) were assessed using the posterior Acromion to Table Distance (ATD) in a supine lying position and a universal goniometer, respectively, pre-intervention and post-intervention for the dominant and non-dominant sides. For statistical analysis, after determining the normality of the data, either a Paired-test or Wilcoxon rank sum test was used to compare the data within each group. Further, either a two-sample Independent t-test or Wilcoxon-Mann-Whitney U test was used to find statistical differences between the two groups at a 5% level of significance.

Results: The subjects had an average age of 24.8±4.07 years and a Body Mass Index (BMI) of 24.10±4.39 kg/m^2, with 11 male and 19 female participants (p-value=0.70), with the right side being the dominant side for all. At baseline, there was no significant difference in the variables between the two groups (p-value >0.05). After the six-week intervention, a significant difference was found in the ATD (dominant pre: 6.17±1.02, dominant post: 3.47±1.05, p-value <0.0001; non-dominant pre: 6.07±1.05, non-dominant post: 3.32±0.92, MD=-2.75; p-value <0.0001) and DF (dominant pre: 16.23±1.37, dominant post: 19.27±1.33, MD=3.03; non-dominant pre: 15.67±1.05, non-dominant post: 19.53±0.74, MD=3.87; p-value <0.0001) in the experimental group. However, the control group revealed a significant difference only for ATD (dominant pre: 6.51±0.89, dominant post: 4.47±0.84, MD=-2.05; non-dominant pre: 6.23±1.00, non-dominant post: 4.41±0.90, MD=-1.82; p-value <0.0001). Additionally, when compared to the control group, the experimental group showed statistically significant results for ATD and DF (p-value <0.05).

Conclusion: The incorporation of ankle muscle strengthening and stretching exercises was found to be more effective compared to the conventional treatment used for correcting RSP.

Keywords: Biomechanics, Exercise therapy, Flexibility, Muscular imbalance, Posture, Strength

INTRODUCTION

The increasing use of smartphones, computers, and tablets for extended periods of time predisposes individuals to cumulative trauma disorder, which could be attributed to prolonged static posture. This subsequently increases the risk of developing postural deformity in the upper body [1]. One such clinical manifestation of postural misalignments is Rounded Shoulder Posture (RSP), with a prevalence of 73% in right RSP and 66% in left RSP in healthy subjects aged 20-50 years [2]. Furthermore, rounded shoulder is a habitual stooped posture where the acromion of the shoulder joint protrudes relative to the Centre of Gravity (COG) of the body, with pronounced scapular dyskinesis (protraction, elevation, and downward rotation) along with an increase in the angle between the upper cervical spine and lower neck bone [1,3,4]. Subsequently, this compensatory action of the postural deformity of RSP produces alterations in the kinematics and orientation at the glenohumeral joint and scapula due to muscular imbalance [4].

The human body is a musculoskeletal system where the movement of every joint is interlinked, and therefore any deviation at one end can lead to alterations at the other. Humans, therefore, require postural control, i.e., the ability of individuals to maintain stability in response to factors that might affect equilibrium [5]. The human body consists of various synergy patterns that help maintain postural control. This basically consists of the activity of various groups of muscles that work in order to maintain equilibrium [6].

In an ideal posture, the Line of Gravity (LOG) passes through the external auditory meatus, bodies of the cervical spine, acromion, and anterior to the thoracic spine, knee, and ankle [6]. Normally, the internal moment forces produced by the soft tissue structures around the joint offset the external moment created by the ground reaction force and gravity [7]. However, postural malalignments exaggerate the location of the LOG, by virtue of which greater internal forces are required to counterbalance the external moment produced by gravity [6,8,9].

Kendall FP et al., state that there should be a vertical alignment between the mastoid process and the midline of the shoulder [10]. However, in RSP, the acromion process is positioned anteriorly relative to the mastoid process, leading to poor alignment of the scapula. These alterations cause greater torque produced by gravitational forces, which is counterbalanced by increased internal forces produced by the shoulder muscles and other soft tissue structures [6,8]. Furthermore, at the lower limb, an external dorsiflexor moment is generated when the LOG is positioned anteriorly in relation to the ankle joint axis. To avoid tibia's forward translation, this external dorsiflexor moment must be countered by an internal plantar flexor moment [6].

In an erect posture, the LOG passes anterior to the medial malleolus, where the pronating effect of the peroneus and plantar flexors is offset by the supinating action of the tibialis anterior in order to stabilise the talonavicular joint. The direct relationship between the degree of stooping and muscle activity of the lower leg muscles is less commonly known. However, electromyographic studies reveal that the action potential of the gastrocnemius and soleus is more pronounced in an upright posture and increases gradually as we progress from a slight to a marked stooping posture, which depends on the position of the lower legs [11-13]. The activity of calf muscles is therefore more pronounced in a stooped posture than in an erect posture [14].

It has been postulated that if certain segments of the body are maintained out of the optimal posture for an extended duration of time, these positions may result in adaptive shortening and lengthening over time [15]. Therefore, the traditional approach targets the stretching and strengthening of the shortened and weakened muscles, respectively, in the involved area [16]. Furthermore, the neurological approach lays emphasis on the functional approach in musculoskeletal problems, which is based on the interaction of the central and peripheral nervous systems, the skeletal and muscular structures involved in the production as well as control of motion [17,18]. It is also believed that it is essential to consider the aspects of posture, movement pattern, and muscle activation [19]. However, none of the Randomised Control Trials (RCTs) have reviewed muscle activation and their related movement pattern as an initial strategy to devise an exercise intervention [20].

Intriguingly, the inclusion of lower extremity exercises to optimise shoulder muscle recruitment patterns is crucial for eliciting potentially favorable outcomes and addressing the deficit in the kinetic chain link and global muscle activation patterns post-shoulder injuries [21,22]. The integrated nature of human functioning has been supported by Garrison JC et al., who compared the lower extremity balance ability of baseball players with Ulnar Collateral Ligament (UCL) tears and found poorer balance in those with injuries, and Moustafa IM and Diab AA observed a reduction in pain and functional improvement in individuals with lumbosacral radiculopathy when subjected to Forward Head Posture (FHP) corrective exercises [23,24]. Therefore, with the increase in the prevalence of RSP, the objective was to introduce an exercise protocol that integrates the kinetic chain, working not only on isolated segments but rather as a dynamic unit.

Given the aforementioned background, it was predicted that the increased activity of the plantar-flexors in association with the stooped posture over a prolonged period of time would further lead to increased stiffness in the gastrocnemius and soleus. Consequently, stretching of the ankle plantar flexors, along with strengthening of the ankle dorsiflexors, will potentiate the stabilisation of the joint and further help in the correction of RSP. Hence, the present study was conducted with the objective to specifically examine the effect of ankle stretching and strengthening exercises, along with conventional scapular stabilisation exercises, on RSP.

MATERIALS AND METHODS

This pilot study was conducted at Amity Institute of Physiotherapy, Noida, Uttar Pradesh, and Prime Hospital and Ortho Centre, Faridabad, Haryana, India from January 2021 to July 2021. The study was done in accordance with the Declaration of Helsinki, and the study protocol was approved by the Institutional Ethical Committee (IEC) with Ethical Clearance Letter Number NTCC/BPT/20-21/JAN.2021/24.

Inclusion criteria: Individuals between the ages of 20-40 years with five or more hours of screen time or desk job, a distance of posterior acromion to table more than 2.6 cm, and anteriorly placed shoulders from the plumb line reference were included in the study.

Exclusion criteria: Individuals with any history of injury, fracture, surgery, or muscle lengthening procedure of lower extremity muscles in the last six months, and those with congenital deformity of the spine were excluded from the study.

Sample size: The study was conducted as a pilot study, and a sample size of 30 was considered in order to meet the objective of the trial. No previous study was conducted to estimate the effect of ankle stretching and strengthening exercises on RSP. Furthermore, the population size was relatively small, and the study was based on convenient sampling adhering to strict COVID-19 norms when the study was conducted.

Procedure

Depending on the findings of this study, the effect of the exercise protocol can be investigated with additional variables. Therefore, 30 healthy individuals with RSP were enrolled in the study and randomly allocated by the chit method into two groups with an allocation ratio of 1:1. The participants were treated by trained physiotherapists in a single-blind trial. The participants were briefed about the study, and written informed consent was obtained prior to the commencement of the study. A physiotherapeutic analysis was conducted prior to enrollment in order to identify RSP. Posture was analysed to identify anterior placement of the shoulders with respect to the reference line. Joint range of motion for ankle dorsiflexion and plantarflexion was also quantified. Questions related to weight, height, demographic details, work profile, along with the duration of time spent in front of a computer or mobile screen, and any areas of pain were collected from the subjects using a self-administered questionnaire, which was designed by an experienced physiotherapist.

Assessment: Subjects in the two groups then participated in their assigned intervention. The control group participated in a combined stretching/scapular strengthening program, and the intervention group participated in a stretching/scapular strengthening program in addition to stretching/strengthening exercises for the ankle. The assessment was done pre and post the six-week intervention.

Assessment of RSP: Assessment of RSP was done in two ways. Firstly, the individuals were assessed using a plumb line reference. In the sagittal plane, the posture was considered to be rounded shoulder if the acromion was placed anterior to the plumb line. Furthermore, in the supine line, the distance between the table and the posterior acromion was measured (ATD=acromion to table distance). If ATD was more than 2.6 cm, it was considered to be RSP [25]. Measurements were taken bilaterally for both the dominant (D) and non-dominant (ND) side.

Assessment of ankle range of motion (rom): Ankle Plantar Flexion (PF) and Dorsi-Flexion (DF) range of motion were measured using a universal goniometer. Measurements were taken bilaterally for both the D and ND side.

Intervention: Following evaluation, the enrolled participants began a six-week program (three times per week). During the first session of intervention, the subjects were shown how to perform the stretching and scapular strengthening exercises. The nature of each exercise was demonstrated and explained by the investigator. Furthermore, the subjects' technique was also evaluated, and feedback was given regarding proper technique.

Control group (Group 1): Participants in the control group were subjected to conventional stretching exercises for the pectoralis and scapular stabilisation exercises. The duration and repetition of each exercise were devised for appropriate activation of the targeted muscles in the case of strengthening exercises and for an appropriate stretch. The protocol consisted of chin tucks [26], which were performed twice a day with a 10-second hold and 15 repetitions. Self-stretch for pectoralis tightness was taught to the subjects, which was performed for a total of 15 repetitions with a 30-second hold. The stretch was performed in a standing position and required the participant to abduct the arm to 90° with the elbow flexed to 90° and the palm placed on a flat palmar surface. The subject then rotated the trunk away from the arm by further increasing the horizontal abduction at the shoulder, maximising the stretch across the chest [27]. Scapular strengthening exercises were done in prone lying, and the formation of W, T, and Y was performed for 15 repetitions with a 10-second hold while maintaining retraction of the scapula. The subject was instructed to lie in a prone position with arms abducted to 90° (the letter T). The subject was then asked to raise their arms above their head and extend the elbow while their arm flexed and abducted to 120° (the letter Y). As for W, the subject was asked to abduct the arm to 90° with the elbows flexed to 90° while maintaining scapular retraction [28,29].

Experimental group (Group 2): In addition to the conventional exercise protocol, stretches for the calf-gastrocnemius and soleus muscles, and progressive strengthening exercises of the dorsiflexors were performed. The stretching exercise protocol was performed with a 30-second hold and 15 repetitions. To perform the first stretch, which is thought to stretch the gastrocnemius muscle, the subject leans onto the wall and keeps the back knee straight until a stretching sensation is felt at the back of the lower leg. To perform the second stretch, which is thought to stretch the soleus muscle, the subject slightly bends their back knee until a stretching sensation is felt at the back of the lower leg. For both stretches, it is important to keep the toes pointed straight forward and the heel of the back foot on the ground [30]. For strengthening exercises for ankle dorsiflexors, the appropriate individual resistance levels were determined. In the first week, the exercise protocol consisted of 10 repetitions of dorsiflexion starting with a green TheraBand, which was progressed gradually every week up to three sets with progression from green to blue TheraBand.

STATISTICAL ANALYSIS

The data were analysed using IBM Statistical Package for the Social Sciences (SPSS) software, version 20.0. The demographic data of the two groups were assessed using an independent two-sample t-test to compare the age and BMI, and a chi-square test was used to compare the gender ratio. Furthermore, with a consideration of a 5% level of significance, p-values were generated within groups using either a paired t-test or Wilcoxon rank sum test to compare the data within each group. Similarly, p-values were generated between groups using either a two-sample independent t-test or Wilcoxon-Mann-Whitney U test to find statistical differences between the two groups. The Hodges-Lehmann estimator has been used to compare the treatment effect when the data are not normally distributed.

RESULTS

The average age of all 30 participants in the two groups is shown in [Table/Fig-1]. The two groups had comparable ages, with no significant difference between them (p-value=0.93). Both the experimental and control groups had participants with normal BMI, and there was no significant difference between the two groups (p-value=0.45) in terms of BMI pre-visit. After six weeks of intervention, there was no significant difference in BMI between the experimental and control groups (p-value=0.57). The study included participants of both genders, as shown in [Table/Fig-1].

Variable	Experimental group (N=15)	Control group (N=15)	p-value*
Age (Years)	24.73±4.04	24.87±4.24	0.93
Gender (Male/Female)	05/10	06/09	0.7048#
BMI (kg/m^2) Pre-visit	24.73±3.56	23.48±5.15	0.45
BMI (kg/m^2) Post-visit	24.67±3.63	23.72±5.21	0.57

[Table/Fig-1]: Descriptive statistics of variables.
Data are mean±SD. SD: Standard deviation
BMI: Body mass index
*p-value generated using independent two-sample t-test
#p-value generated using chi-square test for testing the independence between two groups

In [Table/Fig-2], it can be observed that the Acromion to Table Distance (ATD) significantly improved in both the dominant and non-dominant sides in both the experimental and control groups (p-value <0.0001). The range of motion for dorsiflexors in both the dominant and non-dominant sides showed a significant difference in the experimental group (p-value <0.0001), but no significant difference was found in the control group (p-value >0.05). The range of motion for ankle plantar-flexors revealed no significant difference in both groups (p>0.05) except for plantar flexors of non-dominant side of the experimental group [Table/Fig-2].

Parameter	Pre-intervention (N=15)	Post-intervention (N=15)	Median (IQR)	Mean difference	95% CL	p-value
Experimental group						
D-ATD	6.17±1.02	3.47±1.05	-2.70 (0.50)	-2.71	(-2.86: -2.55)	0.0001*
ND ATD	6.07±1.05	3.32±0.92	-2.80 (0.60)	-2.75	(-2.98: -2.52)	0.0001*
D-D/F	16.23±1.37	19.27±1.33	3.00 (2.00)	3.03	(2.40: 3.67)	<0.0001
ND-D/F	15.67±1.05	19.53±0.74	4.00 (2.00)	3.87	(3.28: 4.45)	0.0001*
D-P/F	48.73±3.15	48.33±2.58	0.00 (2.00)	-0.4	(-1.23: 0.43)	0.32
ND-P/F	49.87±2.70	48.40±2.16	-2.00 (1.00)	-1.47	(-2.12: -0.81)	0.0003
Control group						
D-ATD	6.51±0.89	4.47±0.84	-2.20 (0.40)	-2.05	(-2.27: -1.82)	<0.0001
ND ATD	6.23±1.00	4.41±0.90	-2.10 (0.70)	-1.82	(-2.21: -1.43)	<0.0001
D-D/F	16.20±1.26	16.27±1.16	0.00 (2.00)	0.07	(-0.51: 0.64)	0.8062
ND-D/F	16.13±1.36	16.20±1.08	0.00 (2.00)	0.07	(-0.38: 0.51)	0.7513
D-P/F	49.80±2.73	50.20±2.60	0.00 (1.00)	0.4	(-0.01: 0.81)	0.0541
ND-P/F	50.47±2.17	49.80±1.66	0.00 (2.00)	-0.67	(-1.32: -0.02)	0.0625*

[Table/Fig-2]: Pre-intervention and Post-intervention values for control and experimental group.
D: Dominant; ND: Non dominant; ATD: Acromion to table distance; D/F: Dorsiflexion; P/F: Plantarflexion; IQR: Inter-quartile range; CL: Confidence limits
With consideration of 5% level of significance, p-value generated within groups using either Paired-test or Wilcoxon rank sum test under the assumption of normality. *p-values generated under the non normality assumption

The results from [Table/Fig-3] suggest that there was a significant difference between the experimental and control groups post-intervention in terms of ATD (Dominant side, p-value=0.0169; non-dominant side, p-value=0.01) and ankle dorsiflexion (Dominant side, p-value=0.0002; non-dominant side, p-value <0.0001). This suggests that there was a significant improvement in these variables in the experimental group compared to the control group after six weeks of intervention.

Parameter	Hodges Lehmann		Z-approx	Wilcoxon-Man Whitney p-value
	Interval Midpoint (SE)	95% CL		
Experimental vs Control				
Preintervention				
D-ATD	0.30 (0.41)	(-0.50: 1.10)	0.9763	0.337
ND ATD	0.15 (0.43)	(-0.70: 1.00)	0.3536	0.7262
D-D/F	0.00 (0.51)	(-1.00: 1.00)	-0.0636	0.9498
ND-D/F	0.50 (0.26)	(0.00: 1.00)	1.0284	0.3123
D-P/F	1.50 (1.28)	(-1.00: 4.00)	0.9601	0.3449
ND-P/F	1.00 (1.02)	(-1.00: 3.00)	0.6919	0.4945
Postintervention				
D-ATD	1.05 (0.38)	(0.30: 1.80)	2.535	0.0169
ND ATD	1.15 (0.38)	(0.40: 1.90)	2.7027	0.0114
D-D/F	-3.00 (0.51)	(-4.00: -2.00)	-4.267	0.0002
ND-D/F	-3.50 (0.26)	(-4.00: -3.00)	-4.675	0.0001
D-P/F	2.00 (1.02)	(0.00: 4.00)	1.866	0.0722
ND-P/F	1.50 (0.77)	(0.00: 3.00)	2.1919	0.0366

[Table/Fig-3]: Comparison between the two groups of different intervention (Experimental and Control group) at pre postintervention.
D: Dominant; ND: Non dominant; ATD: Acromion to table distance; D/F: Dorsiflexion; P/F: Plantarflexion. CL: Confidence limits
With consideration of 5% level of significance, p-value generated between groups using either Two-sample independent T-test or Wilcoxon-Mann-Whitney U test under the assumption of normality. *p-values generated under the non normality assumption
Hodges-Lehmann estimator has been used to compare the treatment effect while the data is non normal distributed. Data is not normal in this case

DISCUSSION

The present study aimed to investigate the efficacy of stretching and strengthening ankle muscles in addition to conventional stretching and strengthening of shoulder and scapular complex in individuals with Rounded Shoulder Posture (RSP). Previous research studies [31-33] have compared different treatment protocols for correcting RSP, but none have explored the relationship between rounded shoulders and extensive use of calf muscles due to anterior translation of the center of gravity. Therefore, this study is unique and contributes to the existing literature.

One study examined the effect of self-stretch exercises, McKenzie exercises, and Kendall exercises on RSP and forward head shoulder posture, and found positive results [32]. Similarly, Kluemper et al., suggested that incorporating stretching and strengthening exercises for six weeks can decrease RSP in professional swimmers [34]. These findings are consistent with the results of the present study and support the influence of stretching and strengthening exercises in improving postural abnormalities.

Individuals with RSP have impaired posture due to compensatory structural adjustments at different segments. The results of the present study suggest that stretching the tight anterior shoulder muscles and concurrently strengthening the comparatively weaker scapular muscles have a significant synergistic effect on an individual's posture. These findings align with other research studies that indicate the effectiveness of scapular strengthening exercises in correcting RSP [28,34,35].

Various treatment protocols have been identified to correct rounded shoulders, and many have shown positive outcomes [33,36,37]. One adjunct to conventional treatment protocols is the use of mechanical correction taping, although its effect on RSP remains unclear. One study by Gunaydin et al., found that scapular mechanical correction taping did not show any difference compared to conventional exercises [38]. However, another study reported significant improvements in shoulder posture with the application of corrective taping [39]. The use of mechanical correction taping in RSP is therefore controversial in the literature. Additionally, a study investigating the acute effects of bilateral scapular mechanical correction taping using corrective and rigid tapes found no significant effect [40]. The use of longer Proprioceptive Neuromuscular Facilitation (PNF) interventions has also been suggested to improve RSP [41].

Despite the availability of conventional treatment options, rehabilitation programs now place emphasis on closed kinetic chain exercises that are designed to stimulate weakened structures through motion and force production in adjacent kinetic linked segments [42]. According to the literature, postural malalignments lead to a greater generation of external torque in relation to gravitational forces, which is counterbalanced by greater internal forces induced by muscles and other soft tissue structures. In such situations, ligaments and muscles are required to produce a greater moment to offset the increased gravitational moment and maintain an upright posture [6]. The combination of treatments helps to compensate for the lower leg muscular imbalance, which is a manifestation of poor postural changes.

The present study focuses on stretching and strengthening ankle muscles, and the results obtained are favorable in correcting misaligned posture. A decreased range of motion for ankle dorsiflexors is observed in individuals in both groups, which suggests the prevalence of calf tightness in individuals with RSP. Therefore, subsequent intervention to correct the lower leg muscular imbalance has a positive effect on RSP in individuals in the experimental group.

The findings of the present study indicate that both treatment options are effective in improving RSP. However, the overall results of all indicators are better for participants who performed ankle stretching and strengthening exercises in addition to conventional exercises (p-value <0.05). By addressing the correction of muscular imbalance in the lower extremities resulting from a shift in the center of gravity due to inappropriate malalignment in muscular and structural components elsewhere in the kinetic chain, a subsequent effect on RSP can be achieved.

Limitation(s)

There are a few limitations of the study. The intervention was only six weeks long, so the long-term effects are unknown. Further research is needed to identify and validate the effect of stretching and strengthening lower leg muscles in order to determine the benefits of this novel intervention.

CONCLUSION(S)

Scapular stabilisation exercises, when combined with stretching and strengthening exercises for the ankle, can improve Rounded Shoulder Posture (RSP). This study highlights the importance of using adjunct interventions in other parts of the kinetic chain to achieve superior results, as they have a greater impact on correcting faulty posture. The exercise program used in this study aligns with the biomechanical model and targets the affected structures in the kinetic chain. This paradigm suggests that rehabilitation programs for the upper body should incorporate functional movement patterns and kinetic chain exercises.

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