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Effect of Clubbell Exercises on Shoulder Kinematics in Female Handball Players

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ABSTRACT

Background: Clubbells were popular shoulder exercise equipment used during the 17-18th centuries. Currently there is a resurgence in the use of clubbells to strengthen the shoulder rotators, but there are no studies to prove their effectiveness on shoulder kinematics. Therefore, this study aimed to find out if clubbell exercises had any effect on glenohumeral rotational range of motion (ROM) and shoulder rotator strength. **Methods:** Using a randomised control study design, female handball athletes (n=15) were voluntarily recruited and were assigned randomly to either a handball training only group (HT) (n = 8, age 25±7 y, height 1.77 ± 0.11m, mass 76 ± 15 kg,) or a shoulder exercise group (SE) (n = 7, age 27±8 y, height 1.78 ± 0.12m, mass 79 ± 15 kg). The SE group underwent an exercise programme (8 weeks, 3 days/week, 20 min/day) using clubbells. The ROM and muscle strength were assessed at baseline and at the end of weeks 2, 4, 6 and 8. **Results:** After eight weeks, comparison between groups showed that the SE group's dominant arm internal rotators muscle strength improved (28±5 to 33±7 Nm) significantly ($p<0.05$). Within the SE group, internal rotation ROM, internal rotators, and external rotators muscle strength all significantly ($p<0.05$) improved. **Conclusions:** Clubbell exercises increases internal rotation ROM and shoulder rotators muscle strength. Therefore, it is suggested that handball athletes could use clubbell exercises to improve their shoulder rotational ROM and strengthen the shoulder rotators whereby reducing shoulder injury risk.

Key words: Shoulder Injury, Rotator Cuff, Glenohumeral Joint, Shoulder Kinematics, Clubbell Exercises, Throwing Injuries

INTRODUCTION

The handball throwing action is initiated by abducting the shoulder followed by external rotation and internal rotation. Contraction of the supraspinatus causes abduction at the shoulder and contraction of the large subscapularis leads to internal rotation (David et al., 2000). This internal rotational torque must be equalled by contraction of the external rotators to resist anterior superior humeral translation and to stabilise the glenohumeral joint (Noffal, 2003). This is a repetitive demand on the shoulder rotators during every throwing action in handball. Therefore, performing strengthening exercises to condition the shoulder rotators is essential to reduce injury risk. There are several exercise equipment that could be used to strengthen the shoulder rotators.

Clubbells made of wood are shaped like bowling pins and weigh between 500g to 20kgs. They were popular exercise equipment in India during the 17th and 18th centuries, but their usage declined with the advent of modern exercise machines. Currently there is a resurgence to explore alternate forms of exercise equipment and, clubbells are being used to strengthen the shoulder. But the efficiency of clubbells as a shoulder exercise equipment, has not be studied.

Exercises performed with barbells and dumbbells provide resistance in a single plane and may not simulate a dynamic shoulder action (Walter, 2020). Exercises performed using clubbells may provide better resistance in multiple planes. Performing swinging exercises using the clubbells may improve the glenohumeral range of motion (ROM). Degenerative shoulder conditions such as adhesive capsulitis also benefit from swinging pendular shoulder exercises. Therefore, using clubbells for shoulder exercises may increase glenohumeral ROM and rotator cuff strength. The need to have an optimum rotational ROM and strong shoulder rotators are necessary for athletes participating in overhead throwing sports. One such sport where forceful repetitive shoulder rotations are performed is Handball. Handball athletes execute repetitive explosive shoulder rotations (Achenbach et al., 2020; Walter et al., 2019), this repetitive rotational action causes overuse-related changes to glenohumeral joint stabilisers (Walter, 2020).

Trauma to the shoulder's stabilisers tissues elicits pain and glenohumeral joint area pain is a commonly reported symptom among handball athletes (Andersson et al., 2019). Observational studies indicate that deficits in rotational ROM are due to pathological changes to the stabilising soft tissues

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(Walter et al., 2021; Wang et al., 2000). Rotator cuff weakness has also been observed as a pathological change among handball athletes (Møller et al., 2017). Performing shoulder circumduction exercises are vital for the maintenance of ROM, while providing resistance training to the rotator cuff muscles may strengthen them (Fredriksen et al., 2020). Rotator cuff muscles rotate the humeral head during every throwing action, and compresses it within the within the glenoid cavity maintaining joint stability (Walter, 2020). The large volume of throwing training and match throwing requires the handball athletes to perform thousands of explosive shoulder rotations. Short recovery periods between trainings combined with the large throwing volume may weaken and strain the shoulder rotators over time. To meet the demands of handball throwing, it is recommended to strengthen the rotator cuff muscle and maintain the rotational ROM. Therefore, conditioning the rotator cuff muscles through resistance training will prepare the muscles to meet the demands of the game. Prescribing resistance exercises involving the circumduction movement may improve rotator cuff strength, as well as improve the external and internal rotation ROM (Walter, 2022). Hence, the current study's objective was to find out the effect of a clubbell-based exercise programme on the shoulder kinematics of handball athletes.

METHODS

Participants and Study Design

Human ethics approval (HEC Application 2017/52/LR-PS) was obtained prior to the commencement of the study. Healthy club-level female handball athletes were recruited through advertisement posters to participate in an 8-week shoulder exercise programme. The inclusion criteria were, not having experienced any shoulder injury in the preceding 12 months, being at least 18 years old, competing at the senior club level, and playing competitive handball for the past 5 seasons. Fifteen female handball athletes met the criteria and were recruited.

Study Design

Unblinded randomised control trial design was used for the investigation. All handball athletes were initially measured for their shoulder rotator (internal + external rotators) muscle strength on their dominant arm. A handheld dynamometer was used for measuring muscle strength using the assessment technique described in the testing procedures. After the initial assessment, the handball athletes were ranked based on their dominant-arm rotator cuff muscle strength and randomly allocated via coin toss to a shoulder exercise (SE) or a handball training (HT) only group. The HT group athletes (n=8) had a handball playing experience of 8 ± 2 years, they weighed 76 ±15 kgs, with a height of 1.77 ± 0.11 metres and their ages were 25 ± 7 years. Similarly, the SE group athletes (n=7) had a handball playing experience of 7 ± 2 years, they weighed 79 ± 15 kgs, with a height of 1.78 ± 0.12 metres and their ages were 27 ± 8 years. The randomisation consort flow diagram illustrating the participant flow is shown in Figure 1. Both group athletes underwent two training days and a match-day every week throughout the study duration. During the study period, all the athletes underwent the same duration, type and frequency of handball training and refrained from playing any other sport. None of the athletes underwent any other form of strength or resistance training during the study period.

Testing Procedures

Muscle strength assessment

The assessments were conducted with the athletes lying on an elevated plinth in a supine decubitus position. Muscle strength was assessed using a handheld dynamometer (Microfet3, Hoggan Scientific LLC, Salt Lake City, UT, USA) (Clarke et al., 2011). After a warm-up exercise of two sets of ten shoulder circumduction and rotational movements, the athletes were familiarised with the testing procedures. Then they were asked to execute three shoulder rotational efforts with a 30-second rest interval between each effort. Muscle strength was assessed with the elbow at 90º flexion and the shoulder at 30º abduction (Donatelli et al., 2000). The dynamometer was placed two centimetres proximal to the radius on the dorsal styloid process of the forearm to assess muscle strength of the external rotator. The dynamometer was placed on the forearm's ventral side proximal wrist crease to measure internal rotator muscle strength. The tester positioned the dynamometer in place, and the athletes were instructed to hold their arm in position up against the rotational force for 5-seconds for the manual break tests. The instructions for the manual break tests were "hold as hard as you can: don't let me move your arm." Consistent verbal encouragement was given during the 5-second contraction test period. Three measurements were made with the mean values used for data analysis.

Range of motion assessment

To measure the glenohumeral rotational ROM a goniometer (EGM-422-EMI 12" Elite medical instruments, Fullerton, CA, USA) was used. The active ROM for shoulder external and internal rotation was assessed with the tested side elbow flexed to 90º and the shoulder abducted to 90º (Muir et al., 2010). The goniometer's movable arm was slid along the forearm, the axis was on the olecranon process, and the fixed arm was positioned perpendicular to the floor. Between the tested side's scapula and plinth, a folded towel was wedged for stability. Rotational ROM and muscle strength were assessed at baseline and at the end of every two weeks for eight weeks.

Reproducibility

The investigator evaluated 11 participants (age 24 ± 5 y, mass 81 ± 8 kg, height 1.83 ± 0.11 m) in two separate test sessions with 7 days between sessions for intra-rater reliability. The intra-class correlation coefficient (ICC) scores for three trials were; internal rotation and external rotation ROM, ICC =

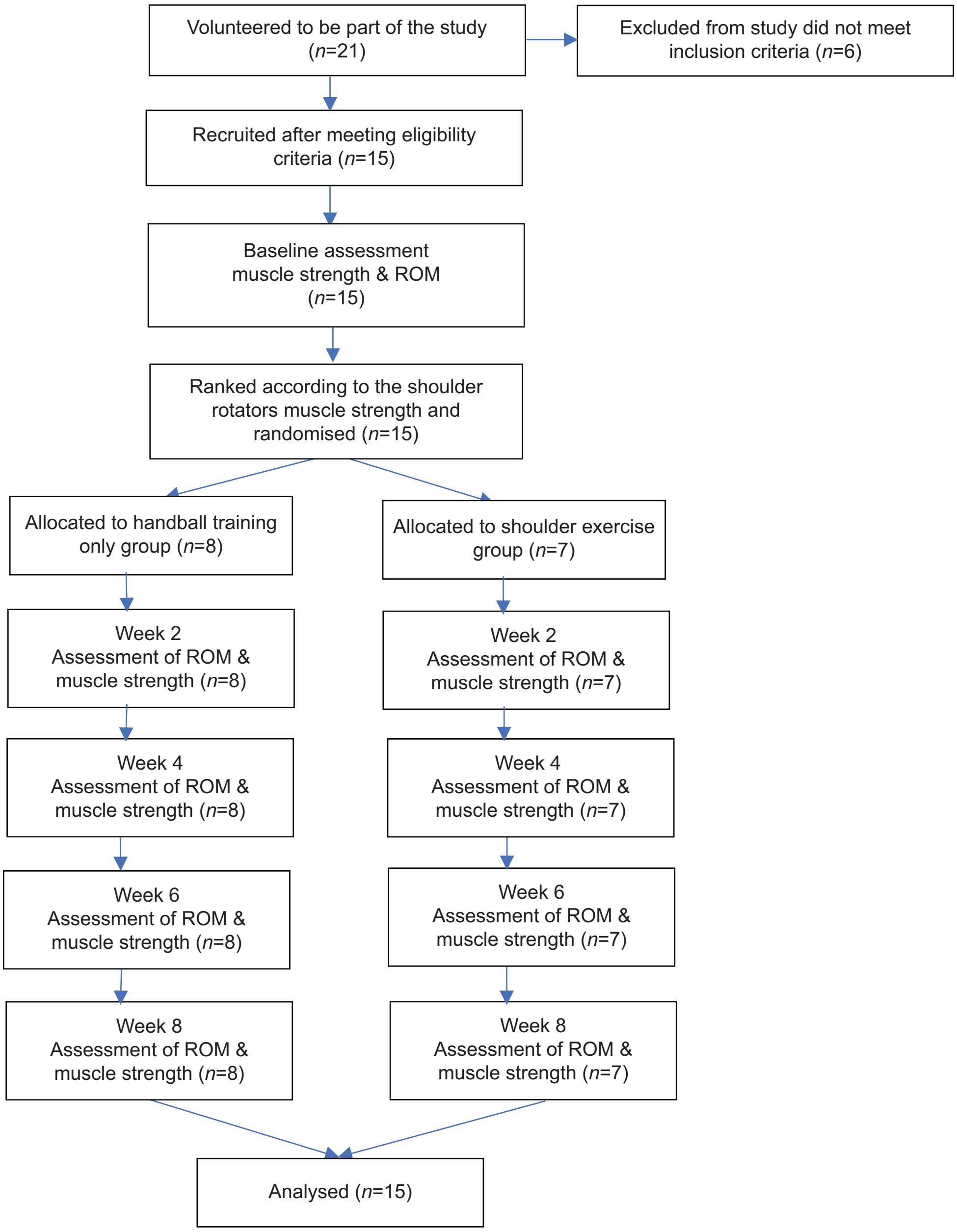

Figure 1. Consort flow diagram of the randomisation and participant allocation through each stage of the 8 weeks study

0.94 (*n*=11, df = 10, 95% CI: 0.84-0.98) and muscle strength, ICC = 0.88 (*n*=11, df = 10, 95% CI: 0.71-0.96). These 11 participants were recruited separately and were not part of the SE or HT group.

The Shoulder Exercise Programme

During the 8-weeks exercise programme the SE group handball athletes performed clubbell exercises 20-min per day on 3 non-consecutive days every week. Clubbells (Purpleheart armoury, USA) made of Oak wood, weighing 500g and 1kg were used. All exercises for the first 4 weeks were executed with the 500g clubbells and then the 1kg clubbells used for the last 4-weeks. Clubbell exercises were demonstrated and taught to the SE group athletes to ensure the correct exercise technique. Demonstration videos and exercise worksheets were also given to the SE group athletes. Every week, athletes in the SE group received an exercise worksheet describing how each exercise was performed its intensity, duration, and frequency. The athletes recorded the exercise time, date, repetitions, and sets. The HT group athletes did not have access to the exercise programme or equipment.

Statistical Analysis

Using two-tailed independent samples t-test, we compared between group changes. Within-group changes over the eight weeks was analysed using two-tailed paired t-tests. The statistical significance level for all data was set at $p<0.05$. Additionally, Cohen's *d* was used to calculate the effect size differences in the muscle strength and ROM from baseline to the conclusion of eight weeks in order to show magnitudes of effects. The effect size was calculated within groups. Effect sizes were then classified as trivial if $d \leq 0.2$, small if *d*

= 0.2 - 0.6, moderate if d = 0.6 - 1.2, large if d =1.2 - 2.0 and very large if d = 2.0 - 4.0, as shown in Table 1.

RESULTS

Muscle Strength

Between group comparisons after 8 weeks showed that the SE groups' internal rotators strength (28±5 to 33±7 Nm) ($p<0.05$) significantly improved on their dominant arm. Comparing baseline to post muscle strength there was a significant ($p<0.05$) increase in both internal and external rotators strength bilaterally within the SE group. The internal rotator muscle strength decreased bilaterally within the HT group athletes.

Range of Motion

After 8 weeks, there were no significant improvements in the rotational ROM between groups. Within the SE group, only the dominant arm's internal rotation ROM increased significantly ($p<0.05$) from baseline (78±6°) to post (84±5°). In comparison it was observed that there was a trivial decrease at 8 weeks in the rotational ROM within the HT group athletes.

DISCUSSION

This is the first study to use clubbells for improving shoulder rotational ROM and muscle strength.

Range of Motion

The current study's exercise programme caused a significant increase in the internal and external rotator strength bilaterally for the SE group athletes. There was also a trivial change in the external rotator strength for the HT group athletes, as both group athletes were actively training and playing matches throughout the eight weeks. We assume that playing demands on the rotator cuff muscles may maintain strength in the HT group athletes. The clubbell exercise programme included internal and external rotation movements; we assume because of this the SE group athletes demonstrated a statistically significant between group increase in their internal rotators muscle strength. Recent studies suggest shoulder injury prevention programmes should include only external rotator exercises as they are the weaker muscle group (Niederbracht et al., 2008). However, an explosive internal rotation movement is needed in all overhead throwing sports as this forceful movement helps deliver the ball with a higher velocity. Therefore, we included both the internal and external rotation movements in the clubbell exercises.

The clubbell exercises were all open kinetic chain exercises performed dynamically and the exercises included glenohumeral rotations and circumduction movements. This method of exercise is beneficial to improve rotational ROM and is used for adhesive capsulitis shoulder rehabilitation (Salwa et al., 2020). The clubbell held in a closed hand acts like a weighted pendulum at the end of a long lever and provides end-range ROM improvement. We assume exercising with clubbells may have helped maintain the rotation ROM

Table 1. Changes to the muscle strength and range of motion throughout the eight weeks

Group & variable	Arm	Baseline	Week 2	Week 4	Week 6	Week 8	Cohen's *d*	Pre to post percentage change*
HT range of motion (°)	ER dominant	99 ± 11	100 ± 7	99 ± 13	101 ± 9	98 ± 10	-0.10	-1%
	IR dominant	75 ± 8	76 ± 7	78 ± 8	75 ± 13	76 ± 14	0.09	1%
	ER non-dominant	100 ± 7	100 ± 6	98 ± 8	95 ± 12	96 ± 11	-0.43	-4%
	IR non-dominant	79 ± 9	71 ± 15	72 ± 15	73 ± 15	74 ± 16	-0.39	-7%
SE range of motion (°)	ER dominant	100 ± 10	103 ± 5	104 ± 6	105 ± 6	106 ± 5	0.76[m]	6%
	IR dominant	78 ± 6[a]	75 ± 6	79 ± 8	80 ± 6	84 ± 5[a]	1.09[m]	7%
	ER non-dominant	98 ± 11	102 ± 6	106 ± 2	104 ± 5	106 ± 5	0.94[m]	8%
	IR non-dominant	79 ± 9	72 ± 9	80 ± 6	86 ± 11	88 ± 10	0.95[m]	10%
HT muscle strength (Nm)	ER dominant	27 ± 6	26 ± 6	28 ± 7	27 ± 6	28 ± 7	0.15	4%
	IR dominant	31 ± 8	33 ± 10	30 ± 10	29 ± 8	29 ± 7[ab]	-0.27	-7%
	ER non-dominant	26 ± 6	28 ± 6	27 ± 6	28 ± 7	28 ± 5	0.36[s]	7%
	IR non-dominant	29 ± 9	29 ± 7	30 ± 11	28 ± 7	28 ± 7	-0.12	-4%
SE muscle strength (Nm)	ER dominant	30 ± 6[a]	29 ± 7	31 ± 7	33 ± 5	34 ± 6[a]	0.67[m]	12%
	IR dominant	28 ± 5[a]	32 ± 8	33 ± 9	35 ± 13	33 ± 7[ab]	0.82[m]	15%
	ER non-dominant	25 ± 3[a]	29 ± 7	31 ± 6	31 ± 5	32 ± 8[a]	1.16[m]	22%
	IR non-dominant	29 ± 10[a]	32 ± 8	32 ± 6	32 ± 7	34 ± 8[a]	0.55[s]	15%

Abbreviation: ER, External rotation; HT, Handball training only group; SE, Shoulder exercise group; IR, Internal rotation; Nm, Newton metre; a = $p<0.05$ comparison presenting baseline and week 8 significant changes within-group, b =$p<0.05$ comparison between SE and HT's week 8 significant changes. Cohen's d effect sizes are trivial if $d \leq 0.2$, small (s) if d = 0.2 - 0.6, moderate (m) if d = 0.6 - 1.2 and large (l) if d =1.2 - 2.0. The effect size was within-group comparison from baseline to week 8. * Relative percentage change calculated within group from baseline to Week 8. Numbers are presented as mean ± SD for the SE group athletes as shown in Table 1. The HT group athletes also played handball for 3 days per week throughout the 8 weeks and their internal rotation ROM on the dominant throwing shoulder did not decrease. Nevertheless, there was a trivial decrease in the rotational ROM on the non-dominant shoulders of the HT group athletes which was not observed in the SE group athletes. Therefore, we recommend active participation in clubbell exercises must be incorporated along with handball training so that it helps maintain rotational ROM throughout the playing season.

Soft tissue adaptations leading to decreased internal rotation and increased external rotation has been an observed among throwing sports athletes (Hadjisavvas et al., 2022). Studies also suggest that soft tissue adaptations due to frequent throwing actions might also be protective against injury. However large deficits in internal rotation are strongly linked to shoulder injury predisposition (Asker et al., 2020). In the current study, athletes who participated in the clubbell exercise programme were able to perform more internal rotation ROM compared to their own baseline internal rotation ROM. As it is hard to describe a perfect internal and external rotation ROM specific to handball athletes (Forthomme et al., 2018), it is recommended to conduct a pre-season assessment of bilateral rotational ROM. This pre-season assessment will help monitor the changes to each athlete's rotational ROM throughout the playing season. By monitoring these changes preventive measures can be undertaken.

Muscle strength

The handball throwing movement is executed quickly and explosively. During this action the latissimus dorsi, deltoids and pectoralis major muscles produce large forces to enable throwing the ball at high velocity (Fredriksen & Tillaar, 2022) At the same time, rotator cuff muscles elicit glenohumeral rotation and humeral head compression in the glenoid cavity (Walter, 2020). The rotator cuff muscles are smaller in comparison to the latissimus dorsi and pectoralis major (Walter, 2020). Therefore, using lighter weights to provide resistance and strengthen the rotator cuff muscles while executing the circumduction movement may benefit them. Even though the clubbells weighed only 500g and 1kg, they were able to provide enough resistance to cause strength adaptations and significantly increased the internal and external rotators strength as shown in Table 1.

Weakness of the external rotators have been associated with changes in the humeral head positioning within the glenoid cavity (Page, 2011). Reduction in the subacromial space has been linked to external rotator weakness (Page, 2011). Furthermore, anterior tilting of the scapula is associated with weakness of the external rotators (Moezy et al., 2014). The larger subscapularis produces more force than the supraspinatus and teres minor and can negatively alter the glenohumeral dynamics (Moezy et al., 2014). Adaptations associated with external rotator weakness leads to impingement-related pain and may affect throwing power. Therefore, it is recommended to increase the strength of the external rotators (Achenbach et al., 2020).

Monitoring pre-season internal and external rotator strength, prescribing clubbell exercises and prospectively monitoring changes throughout the playing season is the most recommended method to reduce rotator cuff-related shoulder injury risk. We wanted both group athletes to undergo the same frequency and duration of handball training every week, to minimise the effect of handball training on the changes to shoulder kinematics, therefore recruiting a large sample of handball athletes from the same training squad was not logistically possible. Therefore, the smaller sample size of the current study is acknowledged as a limitation. Future research must recruit a larger sample size of athletes undergoing the same training every week and then the effect of the clubbell exercise programme must be investigated on their shoulder kinematics.

CONCLUSIONS

A prescribed shoulder exercise programme using clubbell exercises maintains the rotational ROM and improves the rotator cuff muscle strength. Therefore, clubbells can be used as an effective shoulder exercise equipment by handball athletes to improve their shoulder strength and reduce injury risk.

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