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Original Article

Physical Medicine and Rehabilitation Section

Does Shoulder Girdle Strengthening Exercises have an Effect on Grip Strength in Adolescent Recreational Tennis Players? A Randomised Controlled Trial

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ABSTRACT

Introduction: There is a correlation of shoulder girdle strength on grip strength but its effect remains unobserved in adolescent recreational tennis players due to insufficient training time received by recreational players.

Aim: To evaluate the effect of shoulder girdle strengthening exercises on grip strength and to find correlation between shoulder strength and grip strength in recreational adolescent tennis players.

Materials and Methods: The present study was randomised controlled trial, in which 50 adolescent lawn tennis players meeting the inclusion criteria of age range between 9-19 years were selected and randomised into two groups. Group A received shoulder girdle strengthening exercises for three alternate days per week for four weeks whereas no exercises were performed by group B participants. The assessment was done for grip strength and shoulder strength at the baseline, by the end of the 2nd week and by the end of the 4th week for both the groups using hand-held dynamometer and seated medicine ball throw test to see the effect of shoulder girdle strengthening exercises on grip strength. The data was analysed in software MedCalc using repeated measure Analysis of Variance (ANOVA).

Results: The analysis showed statistical significance of p-value <0.001 for both shoulder strength and grip strength in group A in comparison to group B. The correlation between shoulder girdle strengthening on grip strength was found to be r=0.4090, thus revealing a moderate positive correlation between shoulder strength and grip strength after four weeks.

Conclusion: The shoulder girdle strengthening exercises can be incorporated in the training program to improve grip strength as they have a positive moderate correlation.

Keywords: Adolescent recreational tennis player, Hand-held dynamometer, Seated medicine ball throw test

INTRODUCTION

Tennis is one of the most prominent sports played all over the world [1]. The primary shot in the tennis match is service. There are five phases of tennis service: knee flexion trunk rotation, early cocking, maximal abduction external rotation, acceleration and deceleration. The injury incidence was found to be 0.04 to 3 injuries per one thousand hours played for all types of player [1]. Playing tennis involves powerful upper extremity movements repeatedly subjecting the musculoskeletal system to heavy mechanical load, thereby increasing risk for acute and overuse injuries around the shoulder and elbow joint [1]. A study performed by Goulet C and Rogowski I suggested many years of tennis playing could lead to shoulder adaptations in this population, which could potentially maximise the likelihood of degenerative shoulder injuries later in their life thus predisposing these players to develop shoulder injuries, which increases with age [2]. Inconsistent hours of playing can be observed in the players without any prior conditioning. Different levels of sensorimotor processes are required for performing skills and also to protect the muscular system from injury [3].

Playing tennis involves various strokes, out of which the most important strokes are service and forehand ground stroke. These strokes require concentric and eccentric upper extremity musculature work for explosive stroke patterns, which inturn places massive load on the shoulder joint [4]. There is paucity of literature regarding recreational adolescent tennis players as fewer adaptations are found in them owing to the insufficient time of training received by these recreational players. Supraphysiologic powers are produced at the shoulder and elbow due to high ball velocity and racquet positioning placing enormous loads on the joints. Large training volumes, adolescent growth spurts and overscheduling are few of the factors indicating the cause of overuse injuries in upper limb. In the upper extremity, the highest frequency of injury was found in the shoulder and elbow thus, the aim of this study was to evaluate the irradiation effect of shoulder girdle strengthening exercises on grip strength in adolescent tennis players and also to find if any correlation exists between grip strength and shoulder strength amongst the recreational adolescent tennis players.

MATERIALS AND METHODS

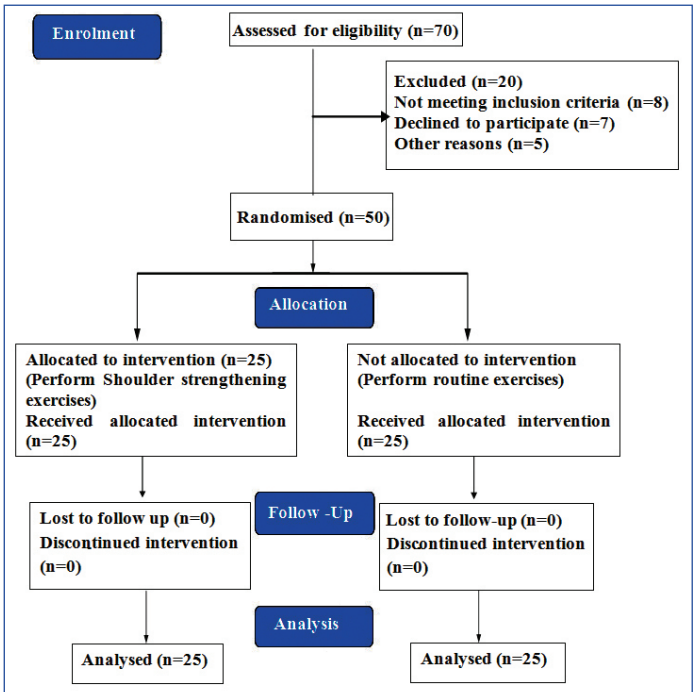
The present study was a randomised controlled trial conducted at Dr DY Patil Vidyapeeth campus Pune, Maharashtra, India between June 2019 to January 2020. A single blinded study where participants were blinded was conducted at tennis academy in Pimpri Chinchwad Municipal Corporation area, Pune after obtaining the Ethical approval (Ref no. DYPCPT/ISEC/14/2019) from the Institute. A consent from the parents of the participants was obtained. A verbal and written consent was also obtained from the participants who fulfilled the inclusion criteria and were willing to participate in the study.

Inclusion criteria: A total of 50 adolescent recreational tennis players in the age group of 9-19 years, having one year of training experience were included in the study.

Exclusion criteria: Participants who had a history of recent soft tissue injuries and recent fractures of the upper extremity were excluded.

Sample size calculation: Sample size was calculated based on the previous study with alpha error=0.05 and power of study 80% [5]. Considering 10% dropouts, final sample size was calculated to be 50.

Hence, 50 eligible participants were selected for the study which was divided into two groups; group A and B, respectively using sealed envelope method. Group A had 16 male and 9 female participants whereas group B had 11 male and 14 female participants [Table/Fig-1]. The participants of group A received shoulder girdle strengthening exercises for a period of four weeks for three alternative days in a week and the group B participants did not perform any type of exercise as they belonged to control group but they continued with their daily routine. The activities performed by the participants as their daily routine and extracurricular activities during four week period of the study were playing basketball, tennis and physical education class in school. Those who were involved in outdoor sports activities involving shoulder girdle strengthening activities were refrained from participating in study.



[Table/Fig-1]: CONSORT 2010 flow diagram.

Outcome Measures

Hand-held dynamometer: The grip strength was assessed using hand-held dynamometer in Kilogram (Kg). It was measured on the dominant hand using a standardised hand-held dynamometer having a modifiable grip. The mean of the three trials was calculated and was taken as mean grip strength [5].

Seated medicine ball throw test: The seated medicine ball throw test assess the glenohumeral as well as arm's strength. The participants were instructed to throw a 2 kg medicine ball in a straight line far away. To eliminate the use of other limbs the participants were made to sit on the surface supporting their back and the ball was held near the neck. Three trials were given and the best of the three scores was considered in inches for scoring [5].

Exercise Performed

The shoulder girdle strengthening exercises were performed for the humeral and scapular muscles to improve the strength of the muscles. The exercises were performed in standing and in comfortable clothing. The initial 10 minutes of the program consisted of general warm-up exercises which included arm circles in multiple directions, side stretch to the right and left and wrist flexion and extension range of motion exercises, each performed for 1 set of 10 repetitions. A set of seven exercises were performed by the participants donning weight cuff.

The following exercises were performed for one set of 20 repetitions [6]:

1) External rotation with shoulder flexed 90°
2) Internal rotation with shoulder abducted 0°
3) Shoulder abduction to 90°
4) Diagonal pattern flexion

The diagonal pattern flexion was performed in standing. The participants performed sequenced movement i.e., flexion, abduction and external rotation ending with extension, adduction and internal rotation [Table/Fig-2].

Joint	Starting position	Ending position
Scapula	Anterior elevation	Posterior depression
Shoulder	Flexion/abduction/external rotation	Extension/adduction/internal rotation
Elbow	Extension	Extension
Forearm	Supination	Pronation
Wrist	Flexion/radial deviation	Extension/ulnar deviation
Fingers	Flexion	Extension

[Table/Fig-2]: Upper extremity D1 flexion- flexion/abduction/external rotation.

Reverse throw: This exercise was performed by the participants in standing position. The participants were told to start the exercise with shoulder extension, adduction, internal rotation, elbow extension, wrist and finger extension with forearm across the midline. The exercise was ended with shoulder flexion abduction and external rotation, elbow and wrist extension which positioned the scapula inward and downward.

Standard forward throw: The participants performed the exercise in standing with shoulder in flexion, abduction external rotation position, elbow and wrist in extension. The exercise was ended with shoulder in extension, adduction, internal rotation with wrist and elbow in extension, mimicking the service stroke.

Rowing: The participants performed this exercise in standing position. With the shoulder in adduction position and the elbow flexed to 90°, the participants were told to retract the shoulder.

All the above exercises were performed along with the weight cuff tied on over the wrist for one set of 20 repetitions by the participants.

STATISTICAL ANALYSIS

The data was analysed using the MedCalc Statistical Package software version 20.0. As the data was normally distributed, Green house-Geisser and Huynh-Feldt test was used to compare the results in between both the groups. Results within the group were compared using Mauchly's spercity test for repeated measure Analysis of Variance (ANOVA). The statistical difference significance was set at $p \leq 0.05$ for all the tests performed. To find the effect of shoulder strength on grip strength, data was analysed and correlation coefficient was done for the participants of group A pre intervention shoulder strength and grip strength and at the end of 4th week of intervention respectively while keeping the confidence interval of 95% for correlation coefficient (r).

RESULTS

The mean age of participants was 12.4±2.29 years in group A and 11.84±1.79 years in group B. [Table/Fig-3] represents mean values of grip strength at baseline, at the end of 2nd week, at the end of 4th week in group A and B, values showed that there was significant statistical difference in the group A when compared with group B. [Table/Fig-4] represents comparison of shoulder strength at baseline, end of two weeks and end of four weeks of intervention in group A and group B, the scores showed that there was significant statistical difference in the shoulder strength of group A when compared with group B.

Statistical significant changes were seen in the grip strength value from baseline to the end of 4th week of intervention in group A [Table/Fig-5].

Grip strength (kg)	Group A (n=25) Mean±SD	Group B (n=25) Mean±SD	p-value
Baseline	18.18±6.13	17.78±5.82	-
Post two weeks	19.53±6.44	18.3±5.92	0.001
Post four weeks	20.84±5.93	18.17±5.73	0.001

[Table/Fig-3]: Comparison of grip strength at baseline, end of two weeks and end of four weeks of intervention in group A and group B.
p-value <0.05 to be considered significant
Greenhouse-Geisser and Huynh-Feldt test was used

Shoulder strength (kg)	Group A (n=25) Mean±SD	Group B (n=25) Mean±SD	p-value
Baseline	65.4±19.43	77.78±29.11	-
Post two weeks	76.84±23.19	77.72±30.9	0.001
Post four weeks	85.72± 25.86	78.92±31.9	0.001

[Table/Fig-4]: Comparison of shoulder strength at baseline, end of two weeks and end of four weeks of intervention in group A and group B.
p-value <0.05 to be considered significant.
Greenhouse-Geisser and Huynh-Feldt test was used

Period	n	Grip strength in A	
		Mean±SD	p-value
Baseline	25	18.18±6.13	-
Post two weeks	25	19.53±6.44	p<0.001
Post four weeks	25	20.84±5.93	p<0.001

[Table/Fig-5]: Table showing comparison of grip strength in group A at baseline, post two weeks and post four weeks.
Mauchly's spercity test was used for repeated measure ANOVA; p-value <0.05 to be considered significant

Statistical significant changes were seen in the shoulder strength value from baseline to the end of 4th week of intervention in group A [Table/Fig-6].

Period	n	Shoulder strength in Group A	
		Mean±SD	p-value
Baseline	25	65.4±19.43	-
Post two weeks	25	76.84±23.19	p<0.001
Post four weeks	25	85.72±25.86	p<0.001

[Table/Fig-6]: Table showing the comparison of shoulder strength at baseline, post two weeks and post four weeks using seated medicine ball throw test in group A.
p-value <0.05 to be considered significant
Mauchly's spercity test was used for repeated measure ANOVA

In [Table/Fig-7] the scores of grip strength showed statistical improvement in group B. The value of group B showed statistical significance for shoulder strength at the end of 4 weeks [Table/Fig-8].

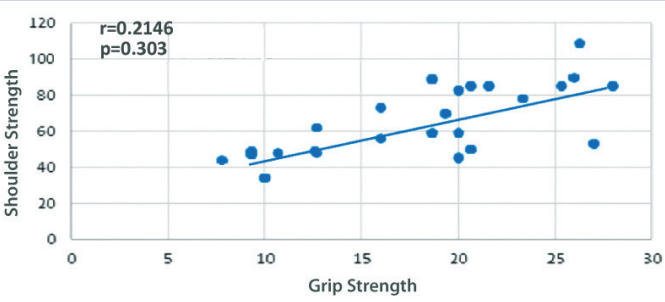
Period	n	Grip strength in Group B	
		Mean±SD	p-value
Baseline	25	17.78±5.82	-
Post two weeks	25	18.3±5.92	p<0.001
Post four weeks	25	18.17±5.73	p<0.001

[Table/Fig-7]: The table showing comparison of grip strength in individuals of group B at baseline, on completion of two week as well as on the completion of four weeks.
p-value <0.05 to be considered significant
Mauchly's spercity test was used for repeated measure ANOVA

Period	n	Shoulder strength in Group B	
		Mean±SD	p-value
Baseline	25	77.78±29.11	-
Post two weeks	25	77.72±30.9	p<0.001
Post four weeks	25	78.92±31.9	p<0.001

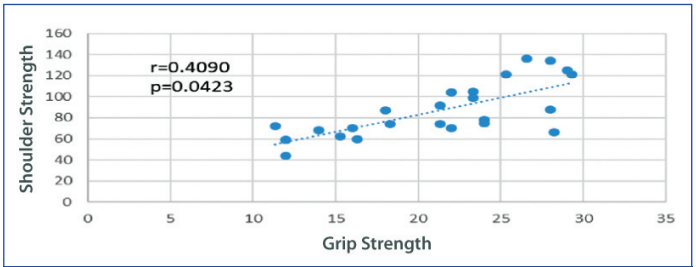
[Table/Fig-8]: Table shows the comparison of shoulder strength at baseline, at end of two weeks and at the end of four weeks using seated medicine ball throw test for group B.
p-value <0.05 to be considered significant
Mauchly's spercity test was used for repeated measure ANOVA

[Table/Fig-9] reveals correlation between pre grip strength and pre shoulder strength in group A, the values showed a moderate positive correlation exist between the pre grip strength and pre shoulder strength in group A.



[Table/Fig-9]: Correlation between the pre grip strength and pre shoulder strength in group A.
*Confidence interval of 95% for correlation coefficient (r) was considered

[Table/Fig-10] shows the scores of correlation between the grip strength and shoulder strength in group A after four weeks of intervention. The scores statistically show a moderate positive correlation exists in group A.



[Table/Fig-10]: Correlation between the grip strength and shoulder strength in group A after four weeks of intervention.
*Confidence interval of 95% for correlation coefficient (r) was considered

DISCUSSION

The purpose of this study was to evaluate the irradiation effect of shoulder girdle strengthening exercises on grip strength in recreational adolescent tennis players. Evaluation of grip strength of participants in group A revealed that, there was a statistically significant improvement in grip strength from the baseline till the end of four weeks of intervention. This change can be attributed to the change in size of type-II B muscle fibres which occurs due to resistance training [7]. Devika B et al., in their study incorporated scapula strengthening exercises targeting the scapular stabilising muscles over the duration of four weeks thrice a week. Their study concluded that grip strength significantly improved in young adults who performed dynamic scapula muscle strengthening exercises [8].

[Table/Fig-4] shows the comparison of shoulder strength in participants of group A at baseline, at the end of 2nd week and of 4th week of intervention. The mean difference between the shoulder strength at baseline and at the end of two weeks was 8 (p<0.001) and at the end of four weeks was 20.32 (p<0.001). Present study results were consistent with the Kachanathu SJ et al., concluded that shoulder stabilisation exercises show significant improvement in shoulder impingement patients, this was due to the elements of the upper quarter as improving proximal stability enhances distal mobility [9]. Swanik KA et al., in their study concluded that functional exercises when incorporated helped to reduce the incidence of shoulder pain but there was no significant difference between groups whereas in within group analysis revealed a significant increase in strength [10].

There was a moderate positive correlation of shoulder strength and grip strength at the end of four week with the r-value of 0.4090 and confidence interval of 95%. This indicates that the

association between the shoulder strength and grip strength was moderate. Cronin J et al., in their study stated that there was an affirmative strong association among shoulder power and grip strength [11]. The type-II muscle fibres have a greater cross-sectional area with the increasing age, the muscle mass increases. Before the age of 20 years the cross-sectional area of type-II muscle fibres which contributes to strength increases 30 fold [12]. They also stated that if the player has decreased shoulder power, their grip strength decreases, and vice versa. Thus, handgrip can be used to predict shoulder strength. Horsley I et al., found out that there is an association between the hand disorder and the higher prevalence of rotator cuff muscle weakness of the upper limb [13].

The principle of proximal and distal motor development postulated by Case-Smith J et al., [14] concluded that in the manipulative and purposeful activities use of arms and hand were hypothesised of being dependent on proximal stability. They also stated that fine movements advance after gross movement is developed. Motor development is being progressed from proximal control to distal control [15]. Sporrong H et al., in their study concluded that in shoulder muscles especially the supraspinatus, a significant increase in the activity was seen in electromyography examination during isometric handgrip strength activity. The activity was also seen improving in the position of shoulder flexion, abduction, and biceps brachia muscles [16].

Thus, considering the effect of shoulder girdle strengthening exercises on grip strength, the handgrip strength can be considered as an indicator for evaluation of proximal muscle strength assessment and a small span training program can be implemented in training sessions for young recreational adolescent tennis players.

Limitation(s)

The long term follow-up after the completion of intervention could not be assessed that can be considered as limitation of the study. Also, gender could have been taken into consideration for analysis. Further study can be performed using electromyography to assess shoulder muscles strength in order to improve the accuracy of the readings obtained.

CONCLUSION(S)

The study concluded that shoulder girdle strengthening exercises help to improve grip strength. Also, a positive moderate correlation between the shoulder strength and grip strength was noted in the experimental group. Thereby, suggesting that shoulder girdle strengthening exercises have a positive effect on grip strength in adolescent recreational tennis players. Thus, the handgrip strength can be used as an indicator of shoulder strength.

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