

Effects of Thrower's Ten exercises on upper extremity performance

A randomized controlled study

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Abstract

Objectives: The Thrower's Ten Exercise program is an exercise program especially designed to improve the strength, power and endurance of the shoulder complex. The aim of this study was to investigate the effects of the Thrower's Ten exercises on the upper extremity performance in healthy sedentary individuals.

Methods: 36 healthy sedentary individuals completed this study conducted with a randomized controlled design. The subjects were divided into 2 groups: exercise and control. The exercise group received a training of the Thrower's Ten exercises of 50-minute sessions 3 times a week for a duration of 8 weeks. Before and after the study, the subjects were tested for dynamic balance on the upper extremity with the Upper Limp Y balance test and for explosive power with the medicine ball throw test. Moreover, the strength of the shoulder internal and external rotator muscles was measured with an isokinetic dynamometer at a speed of 60°/second. The study was registered on the Clinical Trials website by the number NCT04162886.

Results: A comparison between the groups showed significant differences in terms of dynamic balance and explosive power ($P < .05$), but not in terms of isokinetic muscle strength and body composition ($P > .05$). On the other hand, comparisons of the dynamic equilibrium, explosive power and isokinetic muscle strength parameters within the exercise group returned statistically different results ($P < .05$).

Conclusions: The Thrower's Ten exercises represent an effective method to improve the balance on the upper extremity, explosive power and isokinetic strength in healthy sedentary individuals.

Abbreviation: T10 = Thrower's Ten.

Keywords: exercise, power, muscle strength, balance

1. Introduction

The shoulder complex and the wide range of motion and degrees of free movement of the upper extremity, including the elbow and the wrist, present a broad area of work for the hand, as well as opportunities for several multi-joint movement strategies.^[1]

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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Shoulder function is the product of a sophisticated interaction of the shoulder complex with muscles, bones and supporting structures.^[2] The stability of the glenohumeral joint is secured by ligaments and muscle-tendon structures.^[3] Rotator cuff muscles in particular have an important role to play in the joints dynamic stabilization.^[4] The articulations of the shoulder complex provide a series of movements for the shoulder joint and allows complex movements such as throwing. This mobility depends on the controlled and synchronized movement of the shoulder joints.^[5]

Correct and rhythmic operation of the joints in the upper extremity is transferred to the body to aid the postural control and mobility of the body as a whole. However, fatigue resulting from repetitive movements of the shoulder initiates kinematic changes, which in turn affect body movements. Decreased humeral flexion in the upper extremity due to fatigue is compensated by the extension and rotation of the torso.^[1] Therefore, especially in overhead activities, a precise balance between the mobility and stability in the shoulder to meet the functional demands of the shoulder complex in repetitive movements is of crucial importance.^[2] The strength and balance of rotator cuff muscles play a significant role in prevention, or failing that, rehabilitation of injuries because of their functional effect on the shoulders stabilization.^[6] A review of the relevant literature revealed a plethora of intervention and rehabilitation programs designed to help prevent injury.^[7-10] The Thrower's Ten (T10) exercise program which comprises 19 exercises is one of these programs.^[7] This program covers patterns of movement

including throwing-specific motions, high-level neuromuscular control, dynamic stabilization, force, endurance and coordination. EMG studies have confirmed that the program contains exercises that work the shoulder complex and upper extremity muscles in the most active way.^[8-10]

The aim of this study was to investigate the effects of T10 exercises on the upper extremity strength, power and balance in healthy sedentary people.

2. Methods

2.1. Participants

The sample size was determined on the basis of a previous study which determined the effect size of the middle trapezius value as 0.912.^[7] For this reason, for 95% power with the specified effect size ($d=0.912$) and at $\alpha = 0.05$, the required sample size was determined by using the G*Power 3.1.9.2 software.^[7] As a result of the power analysis, it was revealed that a total of 32 participants, 16 from each group, were required. In the case of potential dropouts, the estimated number of the participants was increased by 25%. As a result, the final sample size was calculated as 40. The initial number of volunteers in the study was 40, but 4 left the study due to reasons they specified. The 36 individuals meeting the inclusion criteria of the parallel design study were divided into 2 groups, namely the exercise group ($n=18$) and the control group ($n=18$) randomly using a method based on 1 block randomization by Random Allocation Software (Fig. 1).

Sedentary individuals who were admitted at the University Sports Health Unit were recruited into the study. The eligibility criteria for this study were being between the ages of 18 and 35, having a sedentary lifestyle and being healthy. Moreover, the regular physical activities and sports habits of the individuals were questioned before the study. Individuals who did not do any

regular physical activity, sports or exercise in the last 6 months were considered as sedentary individuals. Individuals with any neurological, orthopedic, cardiovascular, psychological problems, or having had a musculoskeletal injury in the last 1 year were excluded from the study. Before the study, written informed consents were obtained from all participants. This study was approved by the Ethics Committee of the Eastern Mediterranean University in June 2017 (numbered 2017/45-03). All evaluations and exercises in the study were performed at the University Sports Health Unit.

2.2. Procedures

The study was a randomized controlled trial. At least 48 hours before the study (T1), the evaluations to be performed were explained to the participants from both groups, and they were given the opportunity for 1 practice each. Moreover, the exercises to be performed were demonstrated to the exercise group (EG). Those in EG performed T10 exercises for approximately 50 to 55 minutes a day, 3 days a week for the duration of 8 weeks. Each session comprised 5 to 10 minutes of warm-up, approximately 45 minutes of resistance training and 5 to 10 minutes of cool-down.^[11] In the program consisting of 19 exercises, the exercises were performed in 2 sets and 10 repetitions. A break of 1 to 2 minutes was allowed between the sets for resting. Considering the increase in body power and strength in the course of 8 weeks, at the end of 4 weeks (T2), the resistance of the therapeutic bands and dumbbells was progressively increased on the Borg Fatigue Scale (fatigue minutes. 5 and max. 9 points) as in the study published by Buckley and Borg.^[12] The participants in the control group (CG) were instructed not to take part in any physical activity, exercise or sports except for their ordinary daily activities throughout these 8 weeks. All measurements were made before the study and repeated after it ended.

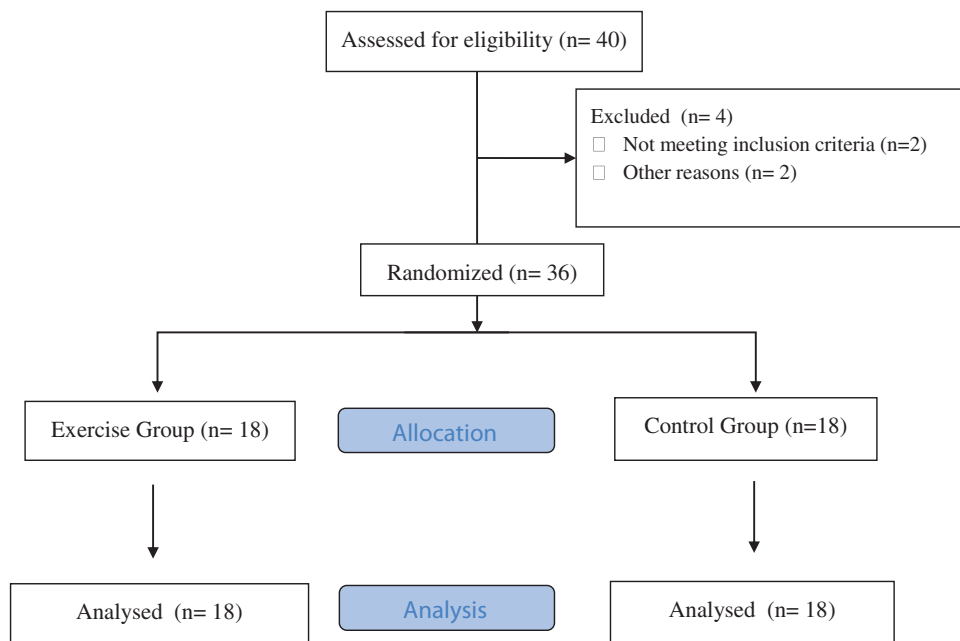


Figure 1. Flow Diagram showing the flow of participants through each stage of trial.

2.3. Outcome measures

2.3.1. Sociodemographic evaluations. The age, sex, physical activity and dominant extremity of the participants were inquired. Moreover, body composition was measured with a professional body composition monitor (TANITA MC-980),^[13] and height was measured in meters with a tape measure.

2.3.2. Dynamic stability of the shoulder joint. In evaluation of the dynamic stability of the shoulder joint, the Upper Quarter Y Balance Test (UQYBT) was used. Before getting started, the participants were allowed to perform tryouts to help them warm up. The participants started in the push-up position to perform UQYBT. Hence, the subjects assumed a “plank” position with 1 hand at the center of the stance plate and both feet placed on the ground and kept the shoulders width apart. While maintaining this push-up position, the contralateral limb of the participants tried to maximally reach 3 distinct directions: medial, superolateral and inferolateral.^[14] The participants returned to the initial position without changing the push-up posture. The length was measured in all directions in cm. 3 tests with the dominant arm were performed, and 1-minute intervals were given between the tests. The mean value of the 3 measurements was recorded. Upper extremity length was calculated to factor in the scoring. The reaching distance was calculated by using the formula [(inferolateral + superolateral + medial) / (3 x length of the upper extremity)] x 100.^[15]

2.3.3. Explosive power. The explosive power of the upper extremity was evaluated with the seated medicine ball throw (SMBT) test. A line was drawn on a flat surface before the test. At the beginning, the subjects sat on this line with their head, back and bottom leaning against the wall and legs extending straight following the line. Their hands were placed on the 2 sides of the wall without fingers touching. Upon the start command, the subjects lifted the ball to the chest and threw it forwards as in a basketball shot. A 2 kg medicine ball was used in the test. Each test was repeated 3 times with 1-minute intervals, and the mean distance was recorded as the measurement result.^[15]

2.3.4. Isokinetic upper limb strength. All isokinetic data were collected from the dominant upper extremity using an isokinetic dynamometer (Cybex Norm). The measurements were performed in a supine position and at a 90° shoulder abduction which is the most reliable and reproducible posture for measurement of IR/ER isokinetic strength in healthy subjects.^[16] The strengths of the upper extremity IR and ER muscles were measured with an isokinetic dynamometer at a 60°/second angular velocity, according to the concentric-concentric protocol and with 5 repetitions. Prior to the actual test, 3 trials were allowed to give the subjects an adequate idea about the range of motion and resistance of the dynamometer. After these trials, the tests were performed with 1-minute intervals for resting.^[17] The test results were recorded as the IR and ER peak torque/body weight (Nm/kg) and agonist/antagonist ratios (IR/ER) for the dominant side.

2.4. Statistical analysis

The data obtained in the study were analyzed using the IBM SPSS Statistics V.22 software (Chicago, Ill., USA). Before statistical tests were used, the normal distribution assumptions of the data were checked with Shapiro–Wilk test. As the $P < .05$ data were not normally distributed, we used non-parametric tests. Mann–Whitney U test was used for the comparison of the continuous

data between the groups, while the categorical data were compared using Chi-Squared and Fishers exact Chi-Squared tests. Wilcoxon signed-rank test was used for the comparisons made before and after the trial. The statistical significance level was taken as $P < .05$. Besides the P value, a confidence interval of 95% (95% CI) and lower and upper limit values were used for statistical significance. If the 95% CI upper and lower limits of the difference between 2 measurements did not cover the “0” value, then, the mean value of these 2 measurements was considered different. The formula used in calculation of the effect size to apply in determining the effectiveness of training was: $r = z / \sqrt{(n \times 2)}$. A small effect was indicated by $r \leq 0.1$, a moderate effect was indicated by $r = 0.3$, and a large effect was indicated by $r \geq 0.5$.^[18]

3. Results

The exercise group and the control group were similar in terms of their mean age, sex, dominant side and body mass index values (P values were respectively; 0.85, 0.83, 0.35 and 0.95) (Table 1).

A comparison of the groups in terms of their UQYBT and SMBT post-test results showed statistically significant differences in both parameters ($P < .05$) (Table 2). When the 95% CI of the post-test measurement differences between variables were calculated, the dominant side was 10.83 to 21.82 for UQYBT (CI 95%) and 15.10 to 127.90 for SMBT (CI 95%) and did not contain the “0” value for either parameter. Therefore, it maintained a statistically significant difference. The intragroup comparisons showed statistically significant differences in EG in the UQYBT and SMBT parameters ($P < .05$). The pre-test and post-test difference in the EG with 95% CI was -22.52 to -11.08 for UQYBT (CI 95%) and -137.21 to -18.79 for SMBT (CI 95%), and neither included the “0” value, meaning that a statistically significant difference was maintained for both parameters. As for the CG, even though there was a statistically significant difference in the in-group comparisons of the SMBT measurements, it was found that the difference between the 2 means included the “0” value when taken together with a CI of 95% (CI 95%: -35.22 – 65.62)., Therefore, a statistically significant difference was not maintained. Furthermore, the effect

Table 1

Socio-demographic characteristics of individuals in exercise and control groups.

Variables	Exercise Group n=18	Control Group n=18	P
Age (years)	24.33 ± 4.95 24 (7.00)	23.83 ± 3.59 24(4.00)	.102*
Gender, n (%)			.717†
Male	5 (27.8)	6 (33.3)	
Female	13 (72.2)	12 (66.7)	
Dominant side, n (%)			.603‡
Right	15 (83.3)	17 (94.4)	
Left	3 (16.7)	1 (5.6)	
BMI, kg/m ²	22.52 ± 4.62 21.0 (7.00)	22.80 ± 3.97 22.00 (5.00)	.845*

Age and BMI values are given as mean ± SD and median (IQR).

* Mann–Whitney U test.

† Chi-Squared test.

‡ Fisher Chi-Squared test.

BMI = body mass index, SD = standard deviation.

Table 2
Intragroup and intergroup comparisons of dominant side Upper Extremity Y Balance Test and Medicine Ball Throw Test, ($\bar{x} \pm \text{sd}$).

	Exercise Group (n = 18)	Control Group (n = 18)	P*
Post-Test	69.1 ± 8.4	74.6 ± 14.3	.21
	85.58 (13.99)	70.50 (12.08)	
	85.9 ± 8.5	69.8 ± 8.4	
	88.82 (17.10)	69.39 (6.41)	
P^{\S}	.00	.08	.00
r	0.62	0.29	
SMBT, cm Pre-Test	320.6 ± 76.5	342.3 ± 81.5	.82
	320.95 (102.02)	322.80 (110.47)	
	398.6 ± 97.1 377.80	327.1 ± 66.6 307.10	
	(164.85)	(133.15)	
Post-Test			.02
P^{\S}	.00	.01	
r	0.62	0.41	

Values are given as mean ± SD and median (IQR).

* Mann-Whitney U test; § = Wilcoxon signed-rank test.

r = Effect size, SD = standard deviation, SMBT = Seated Medicine Ball Throw Test, UQYBT = Upper Quarter Y Balance Test.

size of our outcomes (balance and explosive power) were large in EG ($r > 0.5$) (Table 2).

Comparisons between the pre- and post-test results of the 2 groups in terms of IR/ER at a 60°/second angular speed and the peak torque/body weight ratio for IR and ER returned no statistically significant difference ($P > .05$) (Table 3). On the other hand, a comparison within EG showed a statistically significant difference in the ER peak torque ($P < .05$). However, as the difference between the mean values of the 2 measurements included the “0” value of the lower and upper limits of a CI of 95%, it was determined that a statistically significant difference

was not maintained (CI 95%: -14.13–8.13). It was found that the T10 exercises had a clinically moderate effect on the ER peak torque body weight percentage at an angular speed of 60°/second ($r \geq 4$) (Table 3).

4. Discussion

As a result of this study, which investigated the effects of T10 exercises on the upper extremity balance and muscular strength in healthy sedentary people, it was found that the T10 exercises had a positive effect on the upper extremity balance and explosive power. However, they were not effective on the isokinetic muscular strength of upper extremity rotator muscles at lower angular velocities.

Depending on the combination of static-dynamic balance and interaction between the shoulder complex joints, the stability of the shoulder joints occurs. The activity and coordination of the agonist and antagonist muscles around the shoulder also significantly contribute to stabilization of the shoulder joints.^[19] In this context, we already know that upper extremity exercises are effective on increased shoulder stability and proprioception.^[20] In our study, the upper extremity function was evaluated using UQYBT, which provided information on the mobility and stability of the upper extremity, as well as core stability.^[20] As a result of the study, it was found that the T10 exercises improved the upper extremity stability in the participants. In a study on individuals with subacromial pain syndrome, 6-week general exercises were compared to eccentric exercises on the external rotators of the shoulder, and both treatments had a similar effect on UQYBT responses.^[21] However, it was reported that the low number of subjects in the study might be a factor in the UQYBT results. Wilk et al reported that T10 exercises improved neuromuscular control and contributed to dynamic stabilization by activating the rotator cuff muscles.^[10] Moreover, Patel et al found that T10 exercises also improved rhomboid muscle

Table 3
Intragroup and intergroup comparisons of dominant side isokinetic muscle strength measurement at 60°/second, ($\bar{x} \pm \text{sd}$).

	Dominant Arm	Exercise Group (n = 18)	Control Group (n = 18)	P*
IRMSBWP, (N/m)	Pre-Test	41.6 ± 18.4	45.8 ± 28.7	.94
		30.00 (22.50)	36.00 (43.25)	
	Post-Test	42.0 ± 13.8 39.00 (12.75)	45.8 ± 27.3	.72
			36.00 (37.50)	
P^{\S}		.13	.50	
r		0.25	0.11	
ERMSBWP, (N/m)	Pre-Test	37.3 ± 17.4	40.7 ± 23.8	.87
		30.00 (15.75)	31.50 (43.50)	
	Post-Test	40.3 ± 15.4 36.00 (12.75)	42.2 ± 24.3 33.00 (38.25)	.63
P^{\S}		.01	.72	
r		0.41	0.06	
IR/ER, (N/m)	Pre-Test	93.1 ± 21.1	92.7 ± 22.5	.36
		90.50 (34.50)	88.50 (29.00)	
	Post-Test	95.0 ± 12.6 92.50 (10.25)	93.0 ± 14.4 90.00 (15.50)	.65
P^{\S}		.21	.98	
r		0.20	0.00	

Values are given as mean ± SD and median (IQR).

* Mann-Whitney U test, § = Wilcoxon signed-rank test.

ERMSBWP = External Rotator Muscle Strength Body Weight Percentage, IRMSBWP = Internal Rotator Muscle Strength Body Weight Percentage, IR/ER = Ratio of internal rotators to external rotators, r = Effect size, SD = standard deviation.

strength.^[7] In our study, we think that the T10 exercises which were progressively applied for the duration of 8 weeks improved the stability and mobility of the upper extremity by improving neuromuscular control.

Both in daily life and in sports activities, throwing skills depend on the explosive power of the upper extremity.^[22] In our study, we saw that the T10 exercises improved explosive force. In a study comparing T10 exercises in overhead athletes with a 4-week strengthening program including 2 exercises a week, it was found that the SMBT performance improved in both groups. The same study also found better throwing accuracy. It was suggested that, in both groups, improvement was due to strengthening of the scapular retractor muscles.^[7] Escamilla et al conducted a study with young baseball players that included T10 exercises and found that the exercises were a contributing factor in increased throwing velocity. They reported that the easy and practical T10 exercises might be a factor in increasing throwing velocity as a result of improved strength.^[11] Our study also showed that the T10 exercises with 3 training sessions a week for a period of 8 weeks improved muscle strength and explosive power. Improved muscular strength might have been effective in increasing the throwing distance. Considering that T10 exercises improves the stabilization and balance of the shoulder area in the upper extremity, individuals doing overhead exercises for recreational or competitive purposes may benefit from these exercises against injuries.

In sports or daily activities, the most important feature of a skeletal muscle is the ability to produce force, and this ability itself is a product of movement velocity.^[2,3] On the other hand, injuries of the shoulder are seen frequently as a result of repetitive rapid arm movements performed at a high speed. One possible factor in shoulder injuries is the imbalance between the forces accelerating the upper extremity and those responsible for deceleration.^[24,25] The most common reason for shoulder pain is rotator cuff tendinopathy (RCT). The etiology of RCT includes the muscular imbalance and incoordination between the rotator cuff and scapulothoracic muscles. Balance between the deltoid and rotator cuff muscles is crucial for maintaining the glenohumeral joints function and preventing shoulder pain.^[26] Even if our study showed no statistically significant difference in the IR and ER isokinetic muscle force and IR/ER ratio in the inter- and intragroup comparisons, the clinical observation of the ER muscles in the exercise group showed a moderate increase in strength. Hawkes et al investigated EMG measurements in 3 different shoulder IR exercises and 16 different shoulder girdle muscle activations in healthy individuals. Their results showed that the middle and lower trapezius muscles achieved their highest activation level during the IR exercise at 90° abduction, one of the exercises we used in our study, and the rotator cuff and deltoid muscles, as well as the serratus anterior and rhomboid major muscles, were highly activated.^[27] Furthermore, in their study to evaluate EMG muscle activity, Wilk et al reported that, in prone horizontal abduction at 100 degrees of abduction, one of the most widely used T10 exercises, the supraspinatus muscle and medial and posterior deltoid muscles were significantly more active than in other ER exercises.^[28] In another study, the subjects performed ER exercises (90° abduction and 90° elbow flexion), and it was found that the muscular strength of shoulder external rotators was improved.^[29] As shown in many studies,^[27-29] T10 exercises with a special focus on activating the rotator cuff muscles and other muscles contributing to stabilization of the shoulder may play a part in clinical

improvement of muscular strength by activating the shoulder girdle rotator cuff muscles. This shows that T10 exercises are effective on improving the muscle strength of the shoulder girdle and rotator cuff muscles.

There are some issues which can be considered as limitations of the study. First, this study was conducted in healthy young adults with sedentary lifestyle. Therefore these beneficial effects of exercise should be interpreted with caution for elderly individuals and those with musculoskeletal disorders. Second, although T10 exercises seem safe for clinical use, we are unable to comment on this, as we did not evaluate the complaints of the participants after the exercise program.

5. Conclusion

An 8-week training program with T10 exercises may help improve upper extremity balance, isokinetic muscle strength and explosive power in healthy individuals with a sedentary lifestyle.

Author contributions

Investigation: Ozge Gokalp.

Supervision: Ozge Gokalp.

Methodology: Berkiye Kirmizigil.

Project administration: Berkiye Kirmizigil.

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