Effects of Isokinetic Shoulder Strength Training on Throwing Velocity in Collegiate Female Handball Players

Üniversiteli Kadın Hentbol Oyuncularında Omuz Bölgesine Yönelik Yapılan İzokinetik Kuvvet Antrenmanının Atış Hızına Etkisi

Ahmet YILDIRIM,[a]
Mehmet Settar KOÇAK,[a]
Feza KORKUSUZ[b]

[a]Department of Physical Education and Sports,
Middle East Technical University,
Faculty of Education,
[b]Department of Orthopedics and Traumatology,
Middle East Technical University,
Medical Center, Ankara

Geliş Tarihi/*Received:* 21.03.2008
Kabul Tarihi/*Accepted:* 16.09.2008

Yazışma Adresi/*Correspondence:*
Ahmet YILDIRIM
Middle East Technical University,
Faculty of Education,
Department of Physical Education and Sport, Ankara
TÜRKİYE/TURKEY
yahmet@metu.edu.tr

ABSTRACT Objective : The purpose of this study was to examine the effects of isokinetic shoulder strength training on throwing velocity in collegiate female handball players. **Material and Methods:** Eleven healthy volunteer female collegiate handball players were assigned into experimental (n= 6) and control (n= 5) groups. **Results:** Testing and training for internal-external rotation (IR-ER) of the dominant and non-dominant shoulders were performed by using BIODEX isokinetic dynamometer. Both experimental and control groups were pre and post tested concentrically at 90-180 deg/s and eccentrically 90 deg/s and peak torque (PT) measures were recorded. Experimental group performed three concentric training in a week for four weeks at velocities of 90-120-180-120-90 deg/s and 5-10-15-10-5 repetitions for both dominant and non-dominant shoulders. Three types of shooting style which were mostly used in handball were selected; 1) Three-step shot, 2) Jump shot and 3) Set shot on a spot. Maximum and average throwing velocities (Max-TV, Av-TV) were measured in km/h by a radar gun. four-weeks isokinetic strength training indicated significant differences for Av-TV for jump shot and eccentric PT-ER for non-dominant shoulder in pre and post tests of experimental group while the rest of the variables did not demonstrate significant difference. There was no significant difference in pre and post tests of control group. **Conclusion:** The addition of four-weeks of isokinetic strength training to the handball training resulted in gains only in Av-TV for jump shot and eccentric PT-ER for non-dominant shoulder but rest of the variables did not demonstrate significant difference.

Key Words: Handball; isokinetic strength training; shoulder strength; throwing velocity

ÖZET Amaç: Bu çalışmanın amacı üniversiteli kadın hentbol oyuncularında omuz bölgesine yönelik yapılan izokinetik kuvvet antrenmanının atış hızına etkisini araştırmaktır. **Gereç ve Yöntemler:** On bir sağlıklı kadın hentbol oyuncusu deney grubu (n= 6) ve kontrol grubu (n= 5) olarak ikiye ayrılmıştır. **Bulgular:** Dominant olan ve olmayan kollardaki internal ve eksternal rotasyon kuvvet testleri ve antrenmanları BIODEX izokinetik dinamometre kullanılarak yapılmıştır. Deney ve kontrol gruplarının ön testleri ve son testleri 90 ve 180 °/s konsantrik ve 90 °/s eksantrik olarak ölçülmüştür. Deney grubu dört hafta boyunca haftada üç gün 90-120-180-120-90 °/s hızlarda ve 5-10-15-10-5 tekrarlarda kuvvet antrenmanı yapmıştır. Hentbolde sıkça kullanılan dayanma adımı atışı, üç adımlı dayanma adımı atışı ve sıçrayarak atış türleri seçilmiştir. Radar gun kullanılarak atış hızları saptanmış ve her oyuncunun en yüksek atış hızı (Max-TV) ile ortalama atış hızı (Av-TV) kullanılmıştır. Sonuçlar dört hafta boyunca omuz bölgesine yönelik yapılan izokinetik kuvvet antrenmanının sıçrayarak atış hızının ortalamasını ve dominant olmayan koldaki ekzantrik eksternal rotasyon kuvvet değerinde anlamlı değişmeye sebep olduğunu gösterirken, diğer değişkenlerde anlamlı bir değişikliğe neden olmamıştır. Kontrol grubunda ise ön ve son testler arasında anlamlı bir fark gözlenmemiştir. **Sonuç:** Bu çalışmada hentbol antrenmanına ek olarak yapılan dört haftalık izokinetik kuvvet antrenmanının sadece sıçrayarak atıştaki ortalama atış hızında ve dominant olmayan koldaki ekzantrik eksternal rotasyon kuvvet değerinde anlamlı değişmeye neden olduğu, fakat diğer değişkenlerde anlamlı bir değişikliğe neden olmadığı gözlenmiştir.

Anahtar Kelimeler: Hentbol; izokinetik kuvvet antrenmanı; omuz kuvveti; atış hızı

Turkiye Klinikleri J Sports Sci 2009;1(1):11-6

Throwing velocity and shoulder strength are two important considerations for handball. In handball, the ball should be fast and accurate to the target for desired performance. Sudden and fast arm and shoulder action with the correct technique is very important for scoring a goal.

Injuries in shoulder joint is very common in handball[1] and rehabilitation is very important for athletic performance.[2,3] The nature of handball is open to competition and includes many actions such as; dribbling, passing, and throwing. As handball is an overhead throwing sport as well as the body contact sport, importance is placed on the shoulder joint and its strength and hence the accurate assessment of shoulder muscle performance is important for handball.

Shoulder muscle performance can be assessed either by dynamic or static contractions. Isokinetic measurement provides quantification of torque, work, and power.[4] In addition, isokinetic exercises provide maximal resistance throughout the whole range of motion. Concentric and eccentric types of assessments are two dynamic measurements and shoulder internal rotation (IR) and external rotation (ER) are two essential movements for handball.

In handball throw, internal rotator muscles (deltoid, pectoralis major, subscapularis, coracobrachialis, latissimus dorsi, teres major) act as fast as possible to send the ball to the goal. At this time, external rotator muscles (supraspinatus, infraspinatus, deltoid, teres minor) act reactive movement for deceleration. Stabilization between internal and external rotator muscles plays crucial role to prevent injuries during high velocity arm action.[5-7] Trainers and sport therapists emphasize injury prevention by identifying weaknesses in strength and in bilateral and reciprocal muscle group strength relationship. The ratio between agonist and antagonist muscle group is very important to avoid injuries and show desirable performances.[8-14]

Previous studies indicated that concentric isokinetic torque during shoulder rotation are significantly related to the throwing velocity of a baseball.[15-17] However, this relation is not clear. Clements et al.[16] found that throwing velocity is more related with shoulder internal muscles than external muscles. In contrast, Pedegana et al.[17] found that throwing velocity is mostly related with shoulder external muscles. Moreover, Bayios et al.[18] found no relationship between throwing velocity in set shot and shoulder internal and external rotation.

Wooden et al.[19] stated that isokinetic strength training has no effect on throwing velocity and internal rotator muscle strength. Studies related with isokinetic muscle strength for different sport branches are well documented; however, there are few studies about handball. Hence the purpose of this study was to examine the effects of isokinetic shoulder strength training on throwing velocity in collegiate female handball players.

MATERIAL AND METHODS

SUBJECTS

Eleven healthy volunteer female collegiate handball players, ages 18-23 (20.9 ± 1.7) participated in this study. They were assigned into two groups randomly as: experimental group (n= 6; height: 169.8 ± 1.7 cm; weight: 63.5 ± 5.2 kg; years played: 5.8 ± 1.8) and control group (n= 5; height:167.6 ± 1.8 cm; weight: 58.6 ± 7.6 kg; years played: 6.2 ± 1.8). All subjects were informed about the nature and the purpose of the study and informed consent was signed by the subjects.

ISOKINETIC SHOULDER STRENGTH TEST

Strength measurements of dominant and non-dominant shoulders were tested concentrically and eccentrically at 90 deg/s and concentrically at 180 deg/s before and after the training period by using BIODEX isokinetic dynamometer NY. Testing and training position for shoulder internal and external rotation is shown in Figure 1. Each participant performed two submaximal and then five maximal consecutive contractions. Players were encouraged to perform their best efforts during the tests. Reliability and validity of biodex dynamometry are provided with many studies.[16,20]

FIGURE 1: Testing and training position for shoulder internal and external rotation.

ISOKINETIC STRENGTH TRAINING

Experimental group were trained three times per week for four weeks. All players completed twelve training sessions (total 72). Pyramidal training at 90-120-180-120-90 deg/sec velocities and 5-10-15-10-5 repetitions were performed for both dominant and nondominant shoulders. Four-six weeks period are adequate to test whether the selected strength training is effective.[19,21,22] But these studies were conducted on sedentary people and baseball players. A maximal effort was performed for all trials to develop maximal strength. A thirty second rest period was given between each set.

THROWING VELOCITY MEASUREMENT

Measurements were conducted on a standard size handball court and a goal, and ball speed was measured in km/h by a radar gun, placed behind the goal according to the user manual. Reliability and validity of the radar gun is clear with the previous studies.[15,17] Three types of throwing style which were mostly used in handball were selected.[18] These were 1) Three-step shot, 2) Jump shot and 3) Set shot on a spot. All shoots were performed in front of the 6-meter line. Subjects performed five throws for each style randomly followed by a 10-min warm-up before the test. The maximum throwing velocity (max-TV) and average of two highest throwing velocities (Av-TV) were recorded. Subjects were encouraged to throw the ball as fast as possible.

STATISTICAL ANALYSIS

Multivariate analysis of variances (MANOVA) was used for pretest group comparison and paired sample t-test was used to examine differences between isokinetic strength and throwing velocity for pre and post tests of two groups. Statistical significance level was set at 0.05.

RESULTS

There was no statistically significant difference between experimental and control groups for the pretest (Wilks' = 0.046, $F_{(9,1)} = 2.29$, p= .47).

Pre and post results of mean ball velocities and SDs for three different throwing styles were given in Table 1 for experimental and control groups. Paired sample t-test results demonstrated that there was a significant differences in Av-TV for jump shot ($p < .05$). The results indicated that the mean concern for post-test jump shot (Mean: 64.8, SD: 5.4) was significantly higher than the mean concern for pretest jump shot (Mean: 60.8, SD: 7.6), t(5)= -3.2, p= .024. However, there was no significant difference in Av-TV for 3-step shot and set shot in relation to pre and post test results for experimental groups. In addition, max-TV was not significantly different for the three throwing styles for experimental group. Control group showed no significant differences between pre and post-test results for Av-TV and max TV.

Pre and post test results of mean strength measures (ER, IR and conventional ratio) and SDs for different speeds (concentric 90, concentric 180 and eccentric 90 deg/sec) were given in Table 2 for experimental and control groups. There was no significant difference in isokinetic shoulder strength measures and conventional ratios for pre and post-test results for experimental and control group. In experimental group, the only difference was in ex-

TABLE 1: Throwing velocities for three different shooting styles.

	Pre-test				Post-test			
	Experimental		Control		Experimental		Control	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Set shot on a spot								
Max-TV	57.2	7.3	58	6.1	59.8	3.4	58.6	4.3
Av-TV	56.6	6.9	56.1	6.1	59	3.3	58	4.5
3-step set shot								
Max-TV	59.8	2.8	60.8	7.3	60.5	4.1	59.6	7.1
Av-TV	58.8	3.3	59.4	7.1	60.1	4.1	59.4	7.2
Jump shot								
Max-TV	62.7	7.7	61.6	7.2	65.2	5.4	63	9.1
Av-TV	60.8	7.6	60.9	6.9	64.8*	5.4	61.7	8.6

* p< .05.

TABLE 2: Pre and post-test PT and conventional ratio results for experimental and control group.

	Pre-test				Post-test			
	Dominant		Non-dominant		Dominant		Non-dominant	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
	Control group							
Concentric 90								
ER-PT	24.4	2.9	22.6	3.9	24.2	3.7	23.2	3.8
IR-PT	32.4	4.8	31.5	6.6	33.6	5.7	32.6	7.3
Ratio	0.76	0.06	0.72	0.05	0.73	0.07	0.72	0.06
Concentric 180								
ER-PT	22	1.8	20.2	2.3	23.4	3.8	21.1	2.9
IR-PT	35.5	2.5	33.0	5.3	37.1	3.8	37	5.3
Ratio	0.62	0.05	0.62	0.04	0.63	0.08	0.58	0.06
Eccentric 90								
ER-PT	47.7	8.3	46.9	8.4	48.4	5.4	49.4	6.8
IR-PT	31.5	6.0	36	7.8	37.3	12.1	35.5	11.2
Ratio	1.53	0.22	1.33	0.28	1.40	0.40	1.45	0.30
	Experimental group							
Concentric 90								
ER-PT	27.6	3.2	25.6	2.7	24.3	3.1	22.5	3.0
IR-PT	33.9	3.3	29.1	3.6	35.1	4.1	30.7	4.6
Ratio	0.82	0.05	0.88	0.05	0.69	0.09	0.74	0.1
Concentric 180								
ER-PT	25.2	2.5	23.2	2.6	25.1	5.0	22.1	3.4
IR-PT	34.4	2.8	29	2.1	36.2	5.8	33.3	5.9
Ratio	0.73	0.07	0.81	0.12	0.69	0.07	0.67	0.1
Eccentric 90								
ER-PT	45.7	5.4	41	5.9	49.7	3.6	46.8*	5.4
IR-PT	36.6	5.4	30.4	3.1	34.6	6.4	34.4	4.0
Ratio	1.26	0.16	1.35	0.22	1.47	0.2	1.36	0.1

*p< .05; PT= Peak torque; IR= Internal rotation; ER= External rotation.

ternal rotation-peak torque (ER-PT) measure for non-dominant shoulder. The results indicated that the mean concern for post test ER-PT (Mean= 46.8, SD= 5.4) was significantly greater than the mean concern for pretest ER-PT (Mean= 41, SD= 5.9), t(5)= -2.7, p= .044.

Pre and post-test functional ratio results were given in Table 3. Functional ratios (Ecc ER/Con IR)

TABLE 3: Pre and post-test functional ratio results for experimental and control group.

	Pre-test				Post-test			
	Dominant		Non-dominant		Dominant		Non-dominant	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Eccentric 90 ER/Concentric 90 IR								
Control group functional ratio	1.48	0.21	1.53	0.37	1.46	0.14	1.57	0.40
Experimental group functional ratio	1.35	0.17	1.43	0.30	1.42	0.08	1.54	0.19

for dominant and non-dominant shoulders were ranged between the 1.35 and 1.57.

DISCUSSION

The results suggest that four weeks isokinetic pyramidal strength training was not very functional to improve ball velocity. Max-TVs in three throwing styles were not significant and Av-TVs were not significant for 3-step and set shot. These results were consistent with the previous study in which they found isokinetic strength training had no effect on throwing velocity.[19] On the other hand, Mont et al.[23] stated that isokinetic strength training had an 11% increase in throwing velocity. The present study suspected the increase as there was a slightly improvement in Av-TV for jump shot performance. Similarly, in a previous study, Fleck et al.[24] stated that throwing velocity of a team handball jump shot depends on more on upper extremity strength than does throwing velocity of a team handball set shot.

Based on the results of this study four weeks isokinetic pyramidal strength training was not very effective to improve shoulder strength. Peak torque IR and ER measures for concentric 90-180 and eccentric 90 deg/sec have not changed significantly for dominant and non-dominant shoulders except the eccentric 90 deg/sec ER for non-dominant shoulder. However, this improvement was quite small ($p= .044$). On the other hand, Mont et al.[23] found significant improvement in IR and ER strength for experimental group whose training consisted of 8 sets of 10 submaximal repetitions for six weeks which indicate that higher number of sets and repetitions resulted in improvement in IR and ER muscle strength. In another study Wooden et al.[19] found that ER and IR of PT to body weight (BW) measures did not improve significantly. In their study training duration was five week and their set numbers have increased from 6 to 10 with ten repetitions. Similarly, Bast et al.[21] found no significant difference concentric IR and eccentric IR at the end of four weeks isokinetic training for concentrically trained group. In addition to that, he stated that any training regardless of mode can increase the eccentric strength for ER. The non-dominant eccentric ER strength increased in the present study.

One of the major reasons for shoulder injury is strength imbalance between agonist and antagonist muscles. The conventional and functional ratios of present study provide practical data for sport therapists. But there was no study giving the strength ratios for female handball players. Most of the studies were conducted on baseball players and it is hard to compare the result of present study.

Gorostiaga and his colleagues[22] test the effects of six weeks of heavy resistance training on throwing velocity. They found 3.2% increase in throwing velocity. Mean age of their subjects was 15 and they were male handball players but the mean age in present study was 21 and they were collegiate female handball players. So the age, gender and experience could influence the training effects. In his review, van den Tillaar[25] examined the effect of different training programs on the velocity of over arm throwing. He concluded that there was no clear answer concerning the most effective training on throwing velocity.

This study has some limitations such as; small sample size and short duration of training. Four weeks period possibly was not sufficient to show significant strength gain. Larger sample size with

variability in training design may help to find out more significant findings. Also, subjects of the study were collegiate female handball players and they were not professional. So they had priority to study lessons. Finding of this study could have been affected from players' insufficient motivation or concentration due to the exams.

As a conclusion, four weeks concentric isokinetic training including 5-10-15-10-5 repetitions at 90-120-180-120-90 speeds for dominant and non-dominant shoulder was not very effective to improve strength and throwing velocity except Av-TV for jump shot and eccentric PT-ER for non-dominant shoulder.

REFERENCES

1. Durmaz B. Upper extremities injuries in athletes. Turkiye Klinikleri J Int Med Sci 2006;2(27): 18-28.
2. Mikesky AE, Edwards JE, Wigglesworth JK, Kunkel S. Eccentric and concentric strength of the shoulder and arm musculature in collegiate baseball pitchers. Am J Sports Med 1995;23(5):638-42.
3. Tuncer S. The rehabilitation of shoulder. Turkiye Klinikleri J Int Med Sci 2007;3(27):22-33.
4. Perrin DH, Isokinetic and Exercise Assessment, Champaign, IL: Human Kinetics; 1993.
5. Baltacı G, Tunay VB. Isokinetic performance at diagonal pattern and shoulder mobility in elite overhead athletes. Scandinavian J Med Sci Sports 2004;14(4):231-8.
6. Ellenbecker TS, Davies GJ, Rowinski MJ. Concentric versus eccentric isokinetic strengthening of the rotator cuff, American Journal of Sports Medicine 1988;16(1):64-9.
7. Wang HK, Juang LG, Lin JJ, Wang TG, Jan MH. Isokinetic performance and shoulder mobility in Taiwanese elite junior volleyball players. Isokinetic and Exercise Sci 2004;12: 135-41.
8. Dupuis C, Tourny-Chollet C, Delarue Y, Beuret-Blanquart F. Influence of baseball practice on strength ratios in shoulder rotator muscles: A new position for isokinetic assessment. Isokinetic and Exercise Science 2004;12:149-57.
9. Küçükoğlu HS. Rehabilitation in upper extremities sports injuries. Turkiye Klinikleri J Int Med Sci 2006;2(27):52-5.
10. Sirota SC, Malanga GA, Eischen JJ, Laskowski ER. An eccentric and concentric strength profile of shoulder external and internal rotator muscles in professional baseball pitchers. Am J Sports Medicine 1997;25 (l):59-64.
11. Smedley RB. Peak concentric isokinetic torques of the shoulder rotators in collegiate throwing athletes and non-athletes, UMI Microform 1406953, Bell & Howell Information and Learning Company, 2002.
12. Wang HK, Mcfarlane A, Cochrane T. Isokinetic performance and shoulder mobility in elite volleyball athletes from the United Kingdom. Br J Sports Med 2000;34:39-43.
13. West D, Sole G, Sullivan J. Shoulder external and internal rotation isokinetic strength in master's swimmers. J of Sports Rehabil 2005;14: 12-9.
14. Yıldız Y, Aydın T, Sekir U, Kıralp MZ, Hazneci B, Kalyon TA. Shoulder terminal range eccentric antagonist/concentric agonist strength ratios in overhead athletes. Scandinavian J Med Sci in Sports 2005;16(3): 174-80.
15. Bartlett LR, Storey MD, Simmons BD. Measurement of upper extremity torque production and its relationship to throwing speed in the competitive athlete. Am J Sports Med 1989; 17(1):89-91.
16. Clements AS, Ginn KA, Henley E. Correlation between muscle strength and throwing speed in adolescents baseball players. Phys Therapy in Sport 2001;2:123-31.
17. Pedegana LR, Elsner RC, Roberts D, Lang J, Farewell V. Relationship of upper extremity strength to throwing speed. Am J Sports Med 1982;10:352-4.
18. Bayios IA, Anastasopoulou EM, Sioudris DS, Boudolos KD. Relationship between isokinetic strength of the internal and external shoulder rotators and ball velocity in team handball. J Sports Med Phys Fitness 2001;41(2):229-35.
19. Wooden MJ, Greenfıeld B, Johanson M, Litzelman L, Mundrane M, Donatelli RA. Effects of strength training on throwing velocity and shoulder muscle performance in teenage baseball players. J Orthopaedic Sports Phvsical Therapy 1992;15(5):223-8.
20. Noffal GJ. Isokinetic eccentric to concentric strength ratios of the shoulder rotator muscles in throwers and non throwers. Am J Sports Med 2003;31(4):537-41.
21. Bast SC, Vangsness CT, Takemura J, Folkins E, Landel R. The effects of concentric versus eccentric isokinetic strength training of the rotator cuff in the plane of the scapula at various speeds. Bulletin Hospital for Joint Diseases 1998;57(3):139-44.
22. Gorostiaga EM, Izquierdo M, Iturralde P, Ruesta M, Ibáñez J. Effects of heavy resistance training on maximal and explosive force production, endurance and serum hormones in adolescent handball players. European J Applied Physiology 1999;80(5):485-93.
23. Mont MA, Cohen DB, Campbell KR, Gravare K, Mathur SK. Isokinetic concentric versus eccentric training of shoulders rotators with functional evaluation of performance enhancement in elite tennis players. Am J Sports Med 1994;22(4):513-7.
24. Fleck SJ, Smith SL, Craib MW, Denehan T, Snow RE, Mitchell ML. Upper extremity isokinetic torque and throwing velocity in team handball. J Applied Sports Sci Res 1992;6(2): 120-4.
25. Van den Tillaar R. Effect of different training programs on the velocity of overarm throwing: A brief review. J Strength and Conditioning Res 2004;18(2):388-96.