Medicina Sportiva (2015), vol. XI, no 1, 2513-2518
Journal of the Romanian Sports Medicine Society

Isokinetic specific training protocol in athletes with “handball goalie’s elbow” injury

Hatzimanouil Dimitrios[1], Konstantinos Natsis[2], Giannakos Athanasios[1], Lazaridis Savvas[1]
[1]*Laboratory of Coaching and Sport Performance, Department of Physical Education and Sports Sciences, School of Physical Education and Sports Sciences, Aristotle University of Thessaloniki, Greece*
[2]*Department of Anatomy, Faculty of Health Sciences, School of Medicine, Aristotle University of Thessaloniki, Greece*

Abstract. The aim of the present study was to evaluate the concentric elbow flexion and extension, forearm pronation and supination and wrist flexion and extension torque in handball goalkeepers with “handball goalie’s elbow” injury and to assess the effectiveness of the particular strengthening intervention program. Sixteen top level male goalkeepers who had suffered from elbow injury in the past participated in the study. Pain was the main characteristic of all players. The subjects were divided into an experimental group (N=8) and a control group (N=8). The experimental group underwent a strengthening program with constant resistance using free-weights for three months. The other group (control) was not subjected to any muscular strengthening program. Pre and post the strengthening program all subjects were measured tested for the bilateral peak torque during the concentric flexion and extension of the elbow, pronation and supination of the forearm and flexion and extension of the wrist using an isokinetic dynamometer. The experimental group revealed significant differences only in few parameters regarding the test protocol. More specifically there was a significant increase during the left forearm pronation at 30°/s and at 120°/s ($p<0.01$) and a statistically significant increase during the left wrist flexion at 30°/s ($p<0.01$) between pre and post measurement. It was concluded that the resistance training protocol must be evaluate with more specialization in the training program (isotonic program - isotonic control). Players must perform strengthening protocols in order to prevent “handball goalie’s elbow” using strengthening programs for a long period evaluating muscle strength not only in isokinetic dynamometer.
Key words: *elbow injury, training, concentric.*

Introduction

In team handball there are injuries that occur according to positional role of the player such as the goalkeepers’ injuries in the elbow. Some studies have indicated that during their career a lot of handball goalkeepers (75%), suffered from some kind of elbow injuries. Researchers described these injuries by the term “handball goalie’s elbow”(1-4). This term concerns every clinical finding and symptom that appears in handball goalkeepers’ elbows (5).

All the above mentioned studies claimed that the mechanism underlying the problem of “handball goalie's elbow” is the increased load in hyperextension. The mechanism of this particular lesion is caused most of the times (95%) by violent hyperextension of the elbow due to the intensive impact of the ball, which weights 425-475 g for men and 325-375 g for women and can reach speeds of up to 120 Km/h (1). In fact, 50% of the goalkeepers who suffer from “handball goalie's elbow” present thickening of the medial collateral ligament MCL which was found by ultrasonographic findings (5).

It seems that repetitive hyperextension stress of the elbow in team handball goalkeepers increases medial laxity of the elbow [5]. This laxity ultimately leads to chronic repetitive injuries of the elbow, especially in goalkeepers with low dynamic muscular elbow stabilization (6). Most of the times goalkeepers avoid strength training because they consider this kind of training affect body flexibility which is a main characteristic of the goalkeeper's position. A similar study (7) stated that medial elbow instability may be the result of one traumatic event or represent the cumulative effect of repetitive micro trauma. Thus the main reason for aggravation and the trigger of symptoms is the aggregation of micro trauma (1, 5, 6). The syndrome is not due to previous degenerative distortions, but is likely to be an outcome of repeated minor injuries.

The shot saving or blocking is a movement and specifically is an eccentric type of contreaction where the length of the muscle is augmented (8, 9). Numerous studies have shown that systematic exercise improves the muscle function and the joint stability (4, 10). The activation and the strengthening of the muscles that are adjacent and cooperate with the medial collateral ligament of the elbow joint, may possibly enforce the elbow stability and contribute to the prevention or healing, after an injury of the medial collateral ligament (7). Strengthening exercises is more effective mode from other therapeutic methods, like taping, use of special splint and bracing (1). For all the above reasons, it was suggested strength exercise drills as an extra preventive step for this specific injury (2, 3). Also there is only one study about a rehabilitation program of this injury [4], which however lacks subjects that are professional handball players and a regular adjustment of the workload of the strengthening program during the period of their study.

Thus, the aim of the present study was the evaluation of isokinetic concentric contraction of the upper limbs in handball goalkeepers who suffer from the elbow syndrome, before and after a particular muscular strengthening program with high-load-low-repetition-training regimen.

Material and Method

Due to the small number of goalkeepers in a team, (for example 2-3 maximum) and their frequent participation as basic players in the matches within a year (national championship-cup), it should be designed a flexible and relatively small intervention program for them in order to prevent them from a potential "handball goalkeepers elbow syndrome".

Moreover, physical education teachers and trainers would like to approach this problem-syndrome from a non-clinical view rather than from a training one. For this reason, we have chosen to apply an intervention protocol with resistance training to our subjects.

Sixteen top level male handball goalkeepers of the Greek national league aged 23.6 ± 5.3 years were chosen to participate in the study. They were all active members of their teams for the past two years and had a clinically tested history of elbow symptoms during games and trainings. The complaints related to the "handball goalie's elbow" of an intermittent or even constant pain character. Other complains related to reduced strength and range of motion (ROM), apprehension, numbness, swelling, clicking and a feeling of instability in the elbow joint. Pain was the main characteristic of all players. They were randomly divided into two groups. The first one (8 individuals) served for the experimental group and the second one (8 individuals) for control purposes. The participation was volunteering and the study was designed and carried out according to the guidelines of the Aristotle University of Thessaloniki Ethics Committee. The subjects were informed about the study and provided written informed consent. Their training period was 11.2 ± 4.2 years with an average participation of 5.2 ± 1.4 training per week and an average participation of 30.6 ± 15.2 minutes in their teams' official games.

Immediately prior to the beginning of the playing season the bilateral peak torque during the concentric flexion and extension of the elbow, pronation and supination of the forearm and flexion and extension of the wrist was measured using an isokinetic dynamometer (Cybex Norm Lumex N.Y., USA). The criteria measurements were repeated after three months in the middle of the season. Following the initial measurement the sample (sixteen goalkeepers) was randomly divided into two groups: A (experimental) and B (control). Only group A performed a muscular strengthening program for three months. The other group (control) was not subjected to any muscular strengthening program. All sixteen players continue to play games during the period when muscular strengthening program was executed. The strengthening program was isotonic with resistance training utilizing free-weights. The aim of the program was the development of maximum strength. The program consisted of bilateral strengthening of the tested muscle groups and comprised of 3 sets of 4 repetitions of concentric and eccentric exercises, 3 times a week for 12 weeks (3 sets $_X$ 4 reps $_X$ 3 days $_X$ 12 weeks). The resting time between the sets was about 5 minutes.

The resistance bias was set at a high level of 90% of 1RM for each muscular group. The resistance was individually (for each muscle group) adjusted once a month.

The reliability of the isokinetic dynamometer was checked right before every measurement. The testing was carried out in a supine position. Belts were used to immobilize the trunk and arm and the necessary seat adjustments for elbow and wrist testing were performed.

The subjects familiarized with the procedure with 6-8 testing trials and after 3 minutes of rest they were ready to perform the program.

As far as the elbow flexion and extension is concerned, the test consisted of 3 maximum efforts performed at a velocity of 30°/s and after one minute break at a velocity of 180°/s. For pronation and supination the velocity was set at 30 and 120°/s and for wrist flexion and extension at 30 and 90°/s. The trials were repeated for the contra-lateral limb and the most successful efforts were recorded. Before every training session there was a warm up using mostly upper limb exercises and muscle stretching.

The exercises were divided into six parts. The first part included elbow extension of the right limb. Subjects used the top of an inclined board to perform standing preacher curls supporting their right upper arm on the board. They then gripped a dumb-bell with their palm facing upwards bending the elbow rapidly, drawing the dumb-bell to the shoulder with the help of the other hand. Then, the second repetition was performed. After four repetitions, elbow extension of the left limb was similarly done. The second part involved forearm pronation of the right limb. While kneeling over an exercise bench, holding an one – armed dumb-bell with the weight at the top of the hand with their palm up and the forearm rotated outwards, the dumb-bell was raised as quickly and high as possible. Returning the dumb-bell to the starting position with the help of the other hand the second repetition was attempted. After four repetitions, subjects performed forearm pronation of the left limb.

The third part of exercises was wrist extension of the right limb. Kneeling over an exercise bench holding the dumb-bell in their hand with their palm down the subjects were asked to raise the dumb-bell as quickly and high as possible. The dumb-bell was then returned to the starting position with the help of the other hand and a second repetition was attempted. After four repetitions wrist extension of the left limb as performed. The fourth part included elbow flexion exercise of the right limb using the same mode. After four repetitions elbow flexion exercise of the left limb was similarly done. The fifth part included forearm supination of the right limb with the forearm rotated inwards. After four repetitions the left limb was done with the same mode. The last part was wrist flexion of the right limb having their palm up. After four repetitions the left limb was followed.

The statistical package that was used was the SPSS 12. T-test was used to assess possible improvements between the initial and final measurement of each group (experimental-control). Moreover, an independent sample t-test was used to establish the differences between the experimental and the control group. In order be indicated that the statistical analysis effect and the results to be more comprehensible, the index Eta Squared (E.S.) was used, which is an index that indicates the effect size. The level of significance was set at $p<0.05$.

Results

According to the statistical analysis' results, the measurements were regarded as reliable (Alpha >85 in all variabilities). The experimental group didn't show a statistically significant difference in the right elbow extension at 30°/s and 180°/s and in the left elbow flexion at 30°/s and 180°/s between pre and post training. The control group presented a statistically significant decrease in the right elbow extension at 180°/s between pre and post measurement ($p<0.05$). The above results are presented in Table I.

As far as the left upper limb is concerned, in the experimental group there was a significant increase during the left forearm pronation at 30°/s and at 120°/s between pre and post measurement ($p<0.01$). The control group didn't show any statistically significant differences during the forearm pronation and supination at 30°/s and at 120°/s between pre and post measurement. The above results are presented in Table II. Last but not least, it appeared that the experimental group showed a statistically significant increase during the left wrist flexion at 30°/s, between pre and post measurement ($p<0.01$). The control group didn't show any statistically significant differences during the wrist extension and flexion at 30°/s and at 90°/s between pre and post measurement. The above results are presented in Table III.

Table I. Isokinetic CON peak torque of flexion and extension of left and right elbow 30º&180º

Variables	Experimental group				Control group			
	Pre	Post	p	ES	Pre	Post	p	ES
Flexion Left elbow 30º	47.12±9.70	48.12±9.28		.022	51.00±10.55	48.50±8.05		.20
Extension Left elbow 30º	52.62±15.62	49.00±13.14		.32	61.00±16.60	57.62±12.31		.12
Flexion Left elbow 180º	34.12±9.56	34.25±8.71		.000	36.50±6.84	36.00±3.74		.010
Extension Left elbow 180º	36.25±11.33	39.00±10.78		.14	39.12±7.62	40.12±7.05		.108
Flexion Right elbow 30º	45.25±9.36	44.87±6.89		.009	49.12±13.59	50.50±9.24		.070
Extension Right elbow 30º	53.87±11.72	54.12±14.25		.001	61.25±14.11	58.87±10.42		.077
Flexion Right elbow 180º	34.00±10.60	33.87±7.16		.000	35.25±9.51	37.25±5.41		.098
Extension Right elbow 180º	38.12±9.73	42.25±12.40		.24	43.87±5.76	38.62±5.23	*	.46

*Values are means ± SD (Nm). * p<0,05**p<0,01*

Table II. Isokinetic CON peak torque of pronation and supination of left and right forearm 30º & 120º

Variables	Experimental group				Control group			
	Pre	Post	p	ES	Pre	Post	p	ES
Supination Left forearm 30º	9.00±1.92	9.37±1.30		.054	8.87±1.80	8.62±2.19		.042
Pronation Left forearm 30º	8.12±3.27	11.25±2.76	**	.62	11.25±1.90	10.50±1.51		.32
Supination Left forearm120º	10.12±2.35	10.37±2.44		.012	9.87±1.24	9.37±1.40		.20
Pronation Left forearm120º	8.37±2.82	11.62±2.38	**	.64	10.50±1.51	9.75±1.16		.32
Supination Right forearm 30º	7.12±2.90	9.87±2.85		.42	9.87±4.35	10.00±2.39		.003
Pronation Right forearm 30º	10.12±1.95	9.75±2.76		.018	11.37±3.33	9.37±1.40		.28
Supination Right forearm 120º	8.25±2.37	9.25±2.12		.18	9.87±3.68	10.00±2.20		.002
Pronation Right forearm 120º	9.87±2.03	10.25±2.54		.036	11.12±2.29	10.62±1.30		.071

*Values are means ± SD (Nm). * p<0,05 **p<0,01*

Table III. Isokinetic CON peak torque of flexion and extension of left and right wrist 30º & 90º

Variables	Experimental group				Control group			
	Pre	Post	p	ES	Pre	Post	p	ES
Extension Left wrist 30º	9.25±3.77	10.00±4.65		.098	9.00±5.29	9.62±3.58		.024
Flexion Left wrist 30º	15.50±5.09	18.50±5.78	**	.62	14.37±5.18	15.50±4.86		.10
Extension Left wrist 90º	8.50±3.16	9.75±3.99		.20	9.00±5.70	8.87±2.23		.001
Flexion Left wrist 90º	14.12±5.54	16.75±4.06		.35	14.00±4.78	13.75±5.00		.003
Extension Right wrist 30º	12.00±2.82	12.75±3.84		.055	12.87±3.94	12.75±4.06		.005
Flexion Right wrist 30º	17.25±4.13	18.62±4.29		.17	16.87±3.87	16.50±4.69		.018
Extension Right wrist 90º	11.25±1.98	12.25±3.37		.098	13.25±5.03	12.12±4.70		.11
Flexion Right wrist 90º	15.87±3.52	17.25±3.65		.24	16.25±3.24	15.87±3.52		.015

*Values are means ± SD (Nm). * p<0,05 **p<0,01*

Discussion

In our study it could be stated that there were minimum statistically significant differences during the isokinetic control, concerning the peak torque. Zatsiorsky (11, 12) supports that strength exercises should be attentive to all facets of exercise specificity. Probably there should be maximum statistically significant differences in all movements, if there was an isotonic evaluation (1 RM). In our study the lack of specificity of testing was probably the main reason why there were minimum statistically significant differences during the isokinetic control, concerning the peak torque. Consequently, the players presented minimum statistically significant differences during the isokinetic control, because of their specialization in the training program with constant resistance, while they weren't specialized in an isokinetic control. We consider this was a limitation of the current study. Non-specific training has a high probability of being counter-productive (13). Fleck and Kraemer (14, 15) state that if the strength training and the test evaluation is being performed with the same mode then we have high improvement in the strength. On the other hand if the strength training and the test evaluation are being performed with other mode then the improvement in the strength is minimum or non-existent. Furthermore, in the same study they support that peak torque in low velocities doesn't increase in a significantly higher degree during strength training with a constant resistance, compared to the isokinetic training in low velocities. The above is also shown in the present study, where the isokinetic test velocities were mostly low and medial. Evaluation in low and medial velocities indicate good evidence for the person to resist the press forces that been applied to the joint, while evaluation in high velocities indicate better the muscle ability of the person because these velocities are closer to functional velocities of daily activities (Tsaklis 1997). Fleck and Kraemer (15, 16) state that after 8 weeks of isotonic strength training with a constant resistance and isokinetic training there was an improvement with a constant resistance in maximum rate (1RM) 32% and 4% respectively. On the other hand isokinetic peak torque at the velocity of 60^0/s, had an increasing of 8% after strength training with a constant resistance and 12% after isokinetic training while at the velocity of 240^0/s, the increase was 1% and 10% respectively.

On the other hand we made an effort to simulate the training exercises to the sport movement as closely as possible in terms of movement pattern. As Sale and Macdougall (13) state the movement pattern should replicate the intended activity. In our study we try to develop maximal strength training because Zatsiorsky (11) support that maximal training is regarded as a prerequisite for high movement speed. Thus maximal training may be beneficial because it stimulates maximal adaptation (13).

Another factor that affected the few statistically significant differences during the isokinetic control was probably the big amount of testing repetitions. For example, three movement directions, two velocities in each movement, right and left side were examined and probably this was a reason why players didn't have a lot of statistically significant differences during the isokinetic control.

Although the management of "handball goalie's elbow" is achieved with muscular strengthening, because this method is more effective than others (1) it seems that the effectiveness of the specific test (isokinetic control) wasn't high and didn't show a lot of statistically significant differences. Probably this was also due to the shortness of the period that players performed the program, since Tyrdal and Pettersen (4) state that the effect of strength training and the improvement on the elbow begin after 4.5 months. Thus, the management of "handball goalie's elbow" is not fully achieved since more time is needed. Players must perform strengthening exercises in order to prevent "handball goalie's elbow" using strengthening programs for a long period.

Players must perform strengthening exercises in order to prevent "handball goalie's elbow" using strengthening programs for a long period and evaluate muscle strength not only with isokinetic control. Thus players should probably be able to stand repeated lesions which are caused by violent hyperextension of the elbow due to the intensive impact of the ball. Trainers should support and encourage strengthening exercises although possible improvements should be evaluated with measurements more close to the training programs and not only in isokinetic dynamometer. In this way we may have more information about muscle strength improvement and also goalkeepers may avoid this specific injury.

Acknowledgments. No financial assistance with the project was conducted.

References

1. Tyrdal S, Bahr R: High prevalence of elbow problems among goalkeepers in European team handball -- 'handball goalie's elbow'. *Scand J Med Sci Sports* 1996, 6(5):297-302.
2. Tyrdal S, Olsen BS: Hyperextension trauma to the elbow joint induced through the distal ulna or the distal radius: pathoanatomy and kinematics. An experimental study of the ligament injuries. *Scand J Med Sci Sports* 1998, 8(3):177-182.
3. Tyrdal S, Olsen BS: Hyperextension of the elbow joint: pathoanatomy and kinematics of ligament injuries. *J Shoulder Elbow Surg* 1998, 7(3):272-283.
4. Tyrdal S, Pettersen OJ: The effect of strength training on 'handball goalie's elbow'--a prospective uncontrolled clinical trial. *Scand J Med Sci Sports* 1998, 8(1):33-41.
5. Popovic N, Lemaire R: Hyperextension trauma to the elbow: radiological and ultrasonographic evaluation in handball goalkeepers. *Br J Sports Med* 2002, 36(6):452-456.
6. Tyrdal S, Finnanger AM: Osseous manifestations of 'handball goalie's elbow'. *Scand J Med Sci Sports* 1999, 9(2):92-97.
7. Davidson PA, Pink M, Perry J, Jobe FW: Functional anatomy of the flexor pronator muscle group in relation to the medial collateral ligament of the elbow. *Am J Sports Med* 1995, 23(2):245-250.
8. Grezios AK, Gissis IT, Sotiropoulos AA, Nikolaidis DV, Souglis AG: Muscle-contraction properties in overarm throwing movements. *J Strength Cond Res* 2006, 20(1):117-123.
9. Marques MC, van den Tilaar R, Vescovi JD, Gonzalez-Badillo JJ: Relationship between throwing velocity, muscle power, and bar velocity during bench press in elite handball players. *Int J Sports Physiol Perform* 2007, 2(4):414-422.
10. Deutch SR, Jensen SL, Tyrdal S, Olsen BS, Sneppen O: Elbow joint stability following experimental osteoligamentous injury and reconstruction. *J Shoulder Elbow Surg* 2003, 12(5):466-471.
11. Zatsiorsky VM, Gregory RW, Latash ML: Force and torque production in static multifinger prehension: biomechanics and control. I. Biomechanics. *Biol Cybern* 2002, 87(1):50-57.
12. Zatsiorsky VM, Fortney VL: Sport biomechanics 2000. *J Sports Sci* 1993, 11(4):279-283.
13. Sale D, MacDougall D: Specificity in strength training: a review for the coach and athlete. *Can J Appl Sport Sci* 1981, 6(2):87-92.
14. Fleck SJ, Schutt RC, Jr.: Types of strength training. *Orthop Clin North Am* 1983, 14(2):449-458.
15. Kraemer WJ, Fleck SJ, Evans WJ: Strength and power training: physiological mechanisms of adaptation. *Exerc Sport Sci Rev* 1996, 24:363-397.
16. Kraemer WJ, Deschenes MR, Fleck SJ: Physiological adaptations to resistance exercise. Implications for athletic conditioning. *Sports Med* 1988, 6(4):246-256.

Corresponding author
Savas Lazaridis
Department of Physical Education and Sports Science,
Aristotle University of Thessaloniki
Giannakopoulou 16, 56121
Phone: +32310720671
E-mail: *sav200m@gmail.com*

Received: December 10, 2014
Accepted: February 25, 2015