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The Effect of Proprioceptive Training upon the Upper Limbs Strength on Posttraumatic Shoulder Recovery in Weightlifter Women

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Abstract: This paper aims to examine the effects of proprioceptive training upon upper limbs force in the case of female weightlifters. 10 weightlifters from CSS N. Rotaru in Constanța, Romania, took part in an experiment specially designed for this purpose. The experimental group was assigned a proprioceptive training programme of 15 minutes two times per week, for a period of 20 weeks. The tests administered for the assessment of their upper limbs force were push-ups, push-ups on the Bosu ball, and dynamometry testing. Data analysis shows that no significant differences between the experimental group and the control group are visible at the initial test ($p > 0.05$). In the final evaluation, however, the experimental group obtained better scores than the control group in all tests. These findings indicate that the proprioceptive programme proposed has lead to the enhancement of female weightlifters' muscular force. In conclusion, the programme is an efficient training tool that can be integrated with the sportswomen's exercise routine.

Keywords: *recovery, shoulder, proprioceptive training, weightlifter women, upper limb strength.*

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1. Introduction

In order to obtain good results and to prevent shoulder injuries, no matter the approach used, a sustained and well conducted recovery process is required. The faster the recovery process begins, the better are the results obtained. Thus, we consider that the early and systematic application of proprioceptive means and techniques will lead to the full recovery of the diminished or lost functional capacities.

Proprioceptive training also has the purpose to develop muscular force and neuromuscular control, in order to achieve a better protection of the shoulder joint during the competitions or sports training tasks (Salles et al., 2015). In many cases, coordination and proprioception are neglected by the rehabilitation programs, due to the misjudgement that sportspersons are ready to resume their specific training by means of regained strength and mobility exclusively. If balance, proprioception and coordination are not completely restored, there is a high risk of a relapse (Golshani et al., 2018; Larion et al., 2019; Partin et al., 1994). The inclusion of proprioceptive exercises into the female weightlifters' training programme aims to provide a progressive use for the upper limbs muscles, which will close the kinetic chain and will determine neuromuscular changes of the muscular system, in order to prevent drawbacks caused by injuries (Bălteanu & Bălan, 2014).

Marcu and Dan (2006, pp. 151-152) sustain that proprioceptive training gained rapidly attention in the field of sports performance because of its potential to prevent musculoskeletal injuries, to contribute to their recovery and, at the same time, to improve personal performance. It is grounded in the reprocessing of current neuromotor programmes, starting from the sensory information which created them and through the application of a similar programme, based on new information, that replaces the previous programme, that has become incomplete or needs to be upgraded. Thorugh the use of proprioceptive training, the attempt is to recover the function of the joint, that has been lost after a traumatic event and even to regain of all the motor ability necessary for maintaining the physiological static and dynamic equilibrium of the body (Pásztai, 2001, pp. 148-184). Proprioceptive training is in fact a neuromuscular reprogramming, a technique grounded in the stimulation of the neuromuscular system structures. The main purpose of proprioceptive exercises is to re-educate the proprioceptive reflexes in order to obtain a new optimal level of control upon body muscles and motions. (Cocucci & Boni, 2005, pp. 1-6). Proprioception is important in the process of rehabilitation of

sportspersons' performance because it allows them to adjust their body moves and postures without a permanent conscious control. As Edwards, et al. (2016) sustain, an objective of the shoulder proprioceptive training is to improve muscular force in order to gain the stability of the joint.

At the same time, this type of training is essential for: a full recovery after a trauma of the shoulder joint (for the activation of the reflexes and information channels, which have been altered because of the injury); the prevention of traumatisms (for a higher muscular control during sports tasks and to encourage the use of the entire muscular group, while avoiding isolate contractions); the specific training of sportspeople (to increase the sense of balance and to improve their control over the technical movements) (Avramescu, 2007; Sganzerla, 2020).

Previous research in this field shows the importance of outlining an efficient proprioceptive training programme for women weightlifters, in order to develop the force of their upper limbs. The present study is relevant as it projects, implements and checks a specific workout which is not included in common training programmes for weightlifters. Thus, our goal was to develop, to test and to validate through an experiment the innovative training programme proposed for the development of the upper limbs force of female weightlifters. A further research goal also regarded the possibility of using the programme for prophylactic reasons, in order to prevent injuries occurring during intense sports activities.

2. Methods

2.1. Experimental Design

The experiment included 10 sportswomen, all being sports club members, aged between 18 and 20 years.

For reasons of the present research, they have divided into two equal groups, one forming the control group and another the experimental one. Each group had two specific training programmes per week. The control group subjects (N =5) did not present any existent injuries and / or symptoms at the shoulder level. The experimental group subjects (N =5) accused various symptoms, such as pain or discomfort around the shoulder joint and they all had a medical record of shoulder injuries.

The data regarding the participants' characteristics are presented in table number 1.

Table 1. Identification data of the subjects
Source: Authors' own conception

Groups	Age (years)	Height (cm)	Weight (kg)	Years in training (years)
Experimental (N = 5)	19.00 ± 0.70	164.92 ± 6.47	54.83 ± 4.87	5,91 ± 3.11
Control (N = 5)	18.80 ± 0.83	165.00 ± 6.16	58.16 ± 5.81	6.33 ± 4.80

The purpose of the present research was to highlight the effect of the female weightlifters' proprioceptive training on the functional capacity of the shoulder and on the muscular force of the upper limbs.

We presumed that the weightlifters' recovery programme will be improved by the introduction of proprioceptive exercises. This, in turn, will have a positive effect for the prevention of injuries or damage to the shoulder in the future.

2.2. Training Protocol

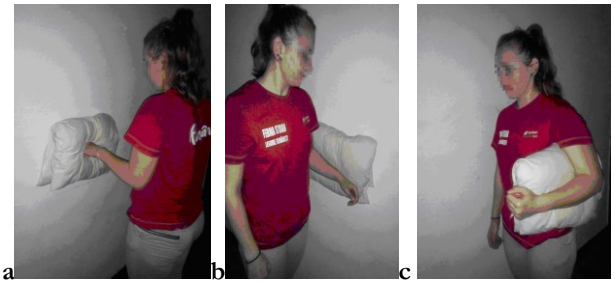
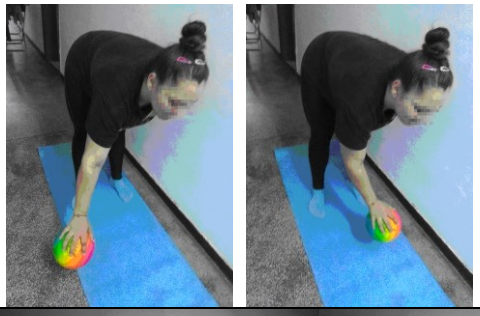
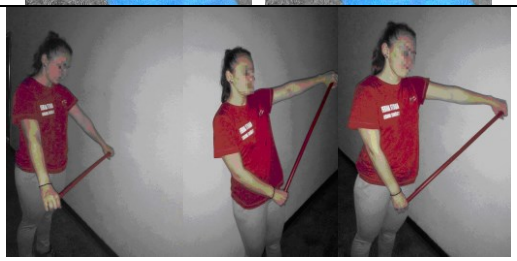
The subjects included into the experimental group performed two different programmes of exercises, as follows: one week of daily proprioceptive stimulation (for a period of 15 minutes), alternated the next week with a daily programme of weightlifting exercises (again, for a period of 15 minutes). As an introduction the sportswomen executed stretching motions, in order to warm up the muscles, ligaments and joints.

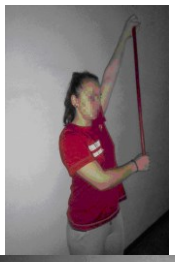
The control group subjects performed only the usual specific training programmes, for the same number of hours as the experimental subjects.

The specific training programmes included:

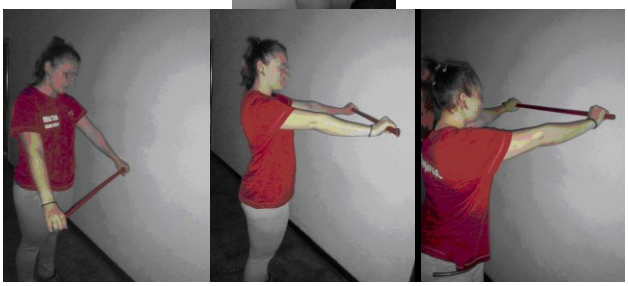
- Isometric contractions of the pectoral arch, insisting on deltoid and rotator muscles;
- Global active contractions of the pectoral arch in a slow motion;
- Proprioceptive exercises performed on unstable platforms (Bossu ball, Swiss ball);
- Weightlifting exercises for strengthening the pectoral arch and the upper limbs: shoulder flexion, extension, abduction, internal and external rotation (table 2).

Table 2. Exercise for the proprioception development

Technical exercise description	**Graphic representation**	**Dosage**
1. Isometric contraction - with elbow flexed at 90^0 : **a)** fist compression by the wall; **b)** arm compression by the wall; **c)** arm compression by the trunk;	 a b c	4 series x 10 repetitions- contraction maintained 6 seconds; pause for 30 seconds.
2. Rolling a ball on the wall, with extended elbow; with elbow flexed at 90^0.		4 series x 10 repetitions; pause for 30 seconds.
3. Upper extended limb inertial balance with a medicine ball in hand (1 kg);		4 series x 30 seconds; pause for 30 seconds.
4. Alternative shoulders abduction with extended elbows, hands gripping a gymnastic stick;		4 series x 30 seconds; pause for 30 seconds.



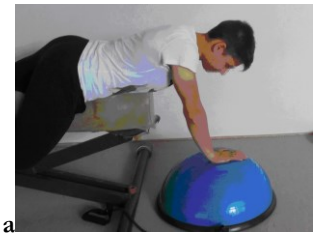
5. Hands grasping the gymnastic stick – shoulders flexion;



4 series x 30 seconds; pause for 30 seconds.

6. a) Maintaining the trunk weight with a hand on the Bosu ball, elbow extended; b) Same exercise, with the hand on a Swiss ball;
c) With the hand in the position a) and B0 – shoulder circumduction , 2 series in each direction;

a



b/c



4 series x 30 seconds; pause for 30 seconds.

7. a) Maintaining the position on a Bosu ball with flat side up, hands apart**;** b) Same exercise with hands together.

a



b



4 series x 30 seconds; pause for 30 seconds.

Source: Authors of work

The research process was conducted in consonance with the relevant ethical guidelines for scientific research. The study was approved by the club's manager and performed according to the principles expressed in the Declaration of Helsinki. Written informed consent was obtained from the subjects. They have been informed that participation in this study was optionally and that they were free to withdraw from the experiment at any moment.

2.3. Evaluation Tests

The sportswomen were tested at the beginning (in October) and at the end of the research (in April) for their upper limbs' strength (by the use of dynamometry and 30 seconds of push-ups) at the „N. Rotaru" Sportive Club and at the Faculty of Physical Education and Sport Constanta sportive base. Based on their score at the test and on their record of past injuries, they were selected to be included into one of the two research groups. The initial values for the somatic and muscular force measurements were similar for all the 10 subjects involved in the study.

The anthropometric measures used in the study were as follows:

- Height, measured in centimeters.

and

- Weight, measured in kilograms.

2.4. Statistical Analysis

The statistical-mathematic method of data processing and interpretation used arithmetic mean value, standard deviation, the significance of the differences between the means. The minimal significance threshold for the statistics was $p = 0.05$.

3. Result and discussion

The values marked at the initial and the final subjects' evaluation for both groups are presented in tables 3 and 4.

Table 3. The "30 seconds pushups" test results for the control and the experimental group
Source: Authors' own conception

Parameters	Push ups				Push ups on Bosu ball			
	T. initial	**T. final**	**t**	**p**	**T. initial**	**T. final**	**t**	**p**

Exp.	**X**	24.40	27.20	5.346	< 0.001	15.20	17.40	5.327	< 0.001
	± DS	0.54	0.83			0.83	0.89		
	CV%	2.24	3.07			5.50	5.13		
Control	**X**	24.00	25.00	1.162	> 0.05	14.80	15.00	0.535	> 0.05
	± DS	0.70	0.70			0.83	1.00		
	CV%	2.94	2.82			5.65	6.66		
	t	1.00	4.490			0.756	4.001		
	p	>0.05	<0.05			> 0.05	< 0.05		

Table 4. The dynamometry test results for the control and the experimental group – initial and final testing
Source: Authors' own conception

Dynamometry - the force of the upper limbs					
		T. initial	**T. final**	**t**	**p**
Exp.	X	23.2	25.80	10.614	< 0.005
	DS	0.83	0.83		
	CV%	3.60	3.24		
Control	X	23.2	23.6	1.633	> 0.05
	DS	0.83	1.34		
	CV%	3.60	5.68		
	t	0	3.110		
	p	> 0.05	< 0.01		

Tables 3 and 4 present the average values (X) of the results obtained in the upper limb strength test (dynamometry and pushups), the standard deviation (DS) for each parameter and the variability coefficient (VC). By analysing the groups' homogeneity, it can be observed a VC < 10%, which shows that both groups had high homogeneity.

3.1. Pushups in 30 seconds - biceps brachial strength testing

The analysis of the results obtained in this test (Table 2) reveals that at the initial evaluation, regardless of the manner of execution, on stable or on unstable platforms, there were no meaningful differences between the two study groups ($p>0.05$). At the final evaluation though, the experimental group registered considerably higher values than the control group, in both types of tests ($p<0.001$; $p<0.05$), as it can be seen in Fig. 1 and 2 presented below.

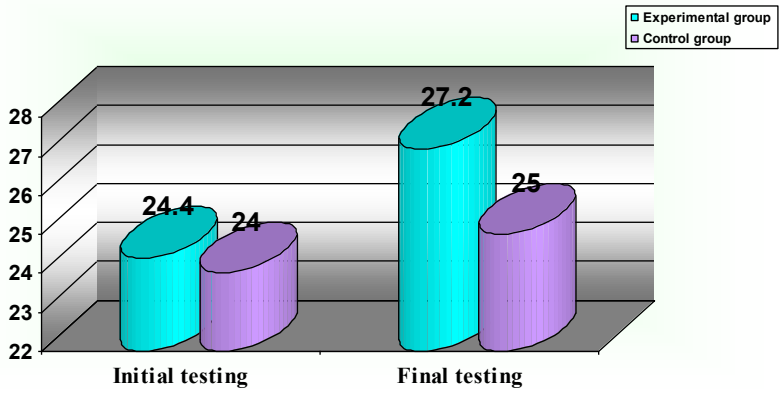


Fig. 1. Upper limbs strength – push-up
Source: Authors' own conception

The interpretation of the statistical data resulting from the testing scores highlights an improvement of the results between the initial and the final evaluation for the experimental group ($t = 5.346$, $p < 0.005$) and measurable progress for the experimental group in comparison with the control one ($t = 4.490$, $p < 0.05$), which registered an irrelevant difference between its initial and final evaluation. Similar results have been obtained by Cazan & Georgescu, (2017) and Watson et al., (2016; 2017) for the sportspeople they tested.

3.2. Push ups on Bosu ball

A similar finding was visible in the case of the Bosu ball testing. The experimental group had better results at the final evaluation than at the initial one ($t = 5.327$, $p < 0.001$), while the values for the control group are not significant ($p>0.05$).

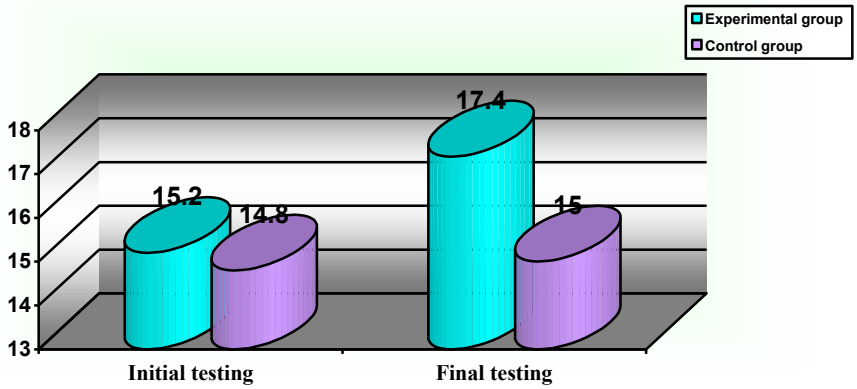


Fig. 2. Upper limbs strength – push-ups on Bosu ball
Source: Authors' own conception

Considering these scores, it can be stated that the experimental subjects (with an average age of 19 years) are qualified as „above average" and „good", progressing from 24.40± 0.54 pushups at the initial testing, to 27.20 ± 0.83 at the final one, while the control group subjects had a lower raising score , with the "above average" standard of - 24.00± 0.70 pushups at the initial test, and 25.00 ± 0.70 at the final one Topendsports (n.d.).(http://www.topendsports.com/testing/tests/home-pushup.htm).

These groups' evolution sustains the hypothesis that the exercises performed have increased the participants' upper limbs strength.

3.3. Dynamometry – upper limb testing

The analyssis of the results obtained in this test (Table nr. 3) shows that the control group has had no relevant progress between the two evaluations ($p > 0.05$), compared to the experimental group, which registered considerably higher values in the final test than in the initial one ($t = 10.614$, $p < 0.001$), as it can be seen in Fig. 3.

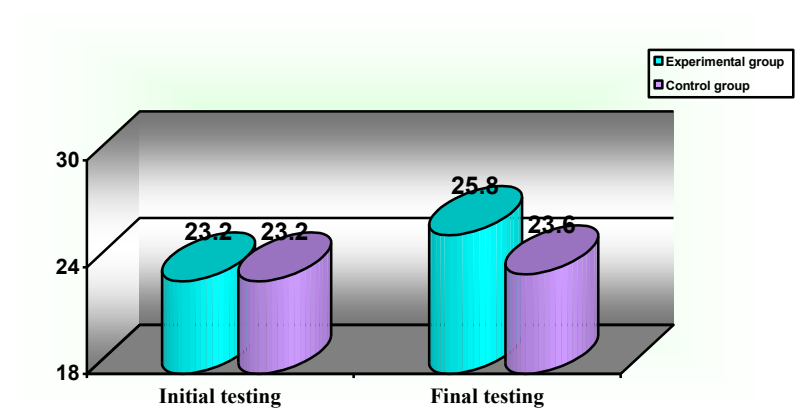


Fig. 3. Upper limbs strength – dynamometry – with the arm next to the body
Source: Authors' own conception

The statistical data interpretation shows that there was no marked difference between the two groups at the initial evaluation ($p > 0.05$), but in the final one a higher score was achieved by the experimental group in comparison with the control one ($t = 3.110$, $p < 0.001$).

The values obtained by the subjects included in this research are higher than those obtained by De, et al., (2011), (16.35 ± 4.89 N). The difference could be explained by the fact that their subjects were not practicing any sport. Horsley, et al., (2016) also found a strong correlation between dynamometry and the shoulder muscular strength ($r = 0.72$).

Following the study results, no matter the testing type, it can be stated that the programmes performed in this experiment have had a general positive influence upon the muscular force developing at the level of the upper limbs.

4. Conclusions

1. At the initial evaluation, at both types of tests, there were no meaningful statistical differences between the two groups ($p > 0.05$).
2. In the upper limb strength test with pushups on stable and unstable platforms, the experimental group subjects obtained better results at the end than at the beginning ($p < 0.005$).
3. They also had better results in the final upper limbs dynamometry test than in the initial one ($p < 0.005$).
4. At the final evaluation, the experimental group marked higher values than the control group for all the tests.

5. We can therefore assert that the experimental design used for this research has proved its efficiency and that the types of exercises used for the achievement of the research objectives have been properly selected and administered in an optimal amount.

Based on the statistical interpretation, it can be stated that the research hypothesis has been confirmed: the proposed proprioceptive training fulfilled its aim, improving the functional capacity of the shoulder and the muscular force of the upper limbs in the case of female weightlifters. The therapeutic activation – through proprioceptive training programmes – of the receptors sensitive to shoulder movements and positions can improve the protective reflex and the neuromuscular control of the joint.

According to Soomro, et al., (2016), Zouita, et al., (2016), Lauersen et al., (2018) as well, the inclusion of proprioceptive training in the sports activities, for at least 15 minutes two times per week, is recommended for the prevention of sports injuries.

Authors' Contributions

GDV conceived the study, performed the literature search, contributed to writing the manuscript, and read and approved the final manuscript. NOV performed and revised the literature search, contributed to writing the manuscript. MGC contributed to writing the manuscript, and read and approved the final manuscript. VF, PD, PAM participated in the design of the manuscript. CND conceived the recovery program, performed and revised the literature search, contributed to writing the manuscript. All authors participated in the revision of the manuscript and figure.

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