

The shot put exercises as an useful component of ballistic training for female boxers

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Summary

Introduction. The shot put is the motion similar to some type of boxing punches. An effectiveness of both those specific efforts depends, in a great part, on the level of upper body explosive strength. This study aimed to test how the inclusion of the shot put exercises into daily boxing drills may improve the performance in highly skilled female boxers after short-term period

Material and methods. The study involved seven national level Polish female senior boxers. They attended in a routine 2-week training camp in the middle of the training season, when their general physical fitness reached the highest level. At the beginning of the camp and in the end of its they completed the same exercise test, consisted of maximal four variant of the shot put, by dominant, non-dominant hand, in habitual and inverse boxer's stances (2 hands x 2stances). Each of those trials consisted of six successive attempts with 1-minute intermissions between them. The best personal outcome of the each type of bout was taken for determination the post training effects. The same exercises with put had been performed every day, in addition to the other the traditional drills recommended for boxers.

Results. The results of mean shots were better when performed by dominant hand, and for both hands after 2-week training, however, they were not dependent on the stances.

Conclusion. The shot put seems to be useful exercise for development and determination of the specific physical ability in boxing

Introduction

In various modern competitive sports the process of conditioning utilizes so-called ballistic exercises. This type of physical training involves strength-explosive movements that use acceleration with fast velocity to move through the space human body or any loads, hence, these movements include throwing, jumping or striking against considerable resistance due to the Earth gravity and/or mass inertia. Thus, ballistic training is practiced, for example, in handball, where the upper body exercises like bench-press is oriented for improvement of ball-throwing velocity, and those parameters are correlated significantly [1-3]. Martial arts players also utilize ballistic exercises to improve their speed of front and side kicks, and palm strikes and to improve [4,5]. In boxing the specific exercises with heavy bag practiced throughout 8 wk punch training period improved coordination and movement time, but not isometric force [6]. Both factors, time execution of a hit and its strength play an important role in successful boxing efficacy. General, appropriate levels of aerobic and anaerobic fitness are achieved by various type of exercises, but where-

as the improvement of ability to throwing of effective punches, sparing fights and blows to the heavy bag are recommended. However, some type of strong punches, such as cross or hook, when hitting the heavy bag with a maximal strength may bring about wrist injury [7,8]. Obviously, much more serious consequences for health result in numerous, repetitive blows executed on a boxer's head. These effects in boxing appears itself usually among former athletes or in those at the end of long sport career as chronic neurological and mental dysfunctions pointing micro-structural damage in the brain damage [9-12]. For that reason in amateur boxing the use of special headgear during an official match is mandatory. While a routine sparing fight, boxing gloves are heavier and more soft to make hits less destructive for performers' hands and opponents' heads. It seems that minimising of the risk of micro-injuries in boxer during his/her traditional punching training might be in part possible due to replacing of hitting the heavy bag by the other efforts of the similar motions, but with effectiveness typical for the ballistic training. It may be assumed that shot put meet the criteria regarding an effectiveness and safety of exercises. The idea of utilizing of shot

put performance for evaluation the effects of training meso-cycle in male boxers has been realized by Lithuanian researchers [13]. They used maximal shot put trials twice, on the beginning and at the end of the 28-day training period oriented on the development of upper body specific strength-velocity abilities, like hitting boxing bag without- and with the load of 0.5-1kg in hands. The bouts of shot put were not performed throughout the training period. That period resulted in the significantly better performance of shot put, compared to the initial state, on average by 3.6% for right and left hand and similar other strength abilities were noted. Moreover, significant correlations ($r=0.83$) between results of shot put and power of straight blows was revealed for right hand. That fact may indicate the high similarity regarding the nature of the movements undertaken when hitting the bag and shot put. after strength-velocity exercise. Additionally, it is worth to note that the mentioned training schedule improved not on shot put performance but also other strength-velocity parameters for lower and upper body limbs, like standing long and high jumps, hand grip strength, number of push-ups, and bending forward arms. However, this paper did not provide detailed information, what stances the performers took while shots put have been executed with both hands, and how various body masses affected the performance.

Based on the above findings, our study aimed to assess the extent of improvement of specific for boxing upper body explosive strength by means of the maximal shot put trials in female boxers following their 2-week routine training with including series of maximal shots put performed every day, by left and right hand with taking both stances, habitual and inverse one.

Material and methods

Polish right-handed female boxers of national level (F1-F7), aged 22.6-32.0 yrs were subjected to this study. The observation was carried out twice, on the beginning and in the end of 2-week training camp that consisted of 2 successive micro-cycles. The subjects completed 14 shot put training including two tests. The first and the second test consisted of four various series of six maximal shot puts performed in standing positions, by left (non-dominant) and right (dominant) hand executed at normal and inverse upright stance. In normal stances the right-handed boxer stands with the legs, when his/her left foot and hand are directed forward (lead extremities) and right foot and hand are directed backward (rear extremities). When throwing the right (rear) hand holding the put is near right side of the chin. The same conditions and circumstances occurred when throwing put with left hand from inverse stances, and both motions i.e. extensions of active arms are synchronized with simultaneous rotation of shoulders and torso. That technique of the movement strongly enhanced energy of the thrown the type of punch named cross and of throws executed by putters. That described above type of motions generated more energy in comparison

to motion when a punch named jab is performed. Jab punch is when lead (front) arm is extended with using triceps brachii only without shoulder and torso rotation. That type of motion was not examined in this study. Hence, instead of shot put-like jab, the put was thrown by left hand (normal stance) and with right hand (inverse stance) with dual-direction of rotation of torso-shoulder complex (T-S), that makes shot put performed by the front hand was similar, regarding the motion, not to jab but to straight punch. Explaining in detail that technique, two consecutive motions of T-S were performed prior to the throw by front hand. At first the T-S together with the hand holding the put have been rotated backward, and subsequently the direction of the rotation was opposite to that, i.e. it has been compatible and synchronized with the extending arm and directed forward.

That T-S counter-rotational motion belong to a family of the motions known as counter-movements. During boxing fight those motions take place during performing of fast series of successive left and right punches, hooks and /or crosses performed with a penetrating power alternately to an opponent's head or trunk. Those type of punches are executed when an opponent is very fatigued and or somewhat stunned. In that case the punches bring about so huge dominance of the performer over his opponent, that a referee often stops the fight to avoid heavy knock-out.

In our study to avoid effect of neuromuscular fatigue accumulation during the tests and an effect of interaction between successive throws, 1-minute intermissions separated each shot, and the various bouts were performed in a randomized order. Maximal shots were preceded by few sub maximal ones. The Wilcoxon matched-paired signed-rank test was used for detection of differences between mean results and between dispersion of single shots within each the series of six shots performed before and after trainings. That dispersion is express as $CV\%=(SD/mean \text{ from six shots})\cdot 100\%$. The program of STATISTICA software, version 9.0, StatSoft USA was used for calculation. The experiment was approved by Ethical Commission at Institute of Sport.

Results

Results of the best shots put under various conditions are displayed in Table 1 and Table 2. Within-subject variability (CV%) of the series of six attempts of the each type of the shot put is expressed in Table 3.

The results showed significant differences between the mean results attained with respect to the terms and the hand. On average, considering both terms, hands and stances, after the physical performance has been improved after trainings by 7.3%. Surprisingly, a taken stance did not influence on the performance of dominant or non dominant hand. For each stance, normal and inverse, and in both study sessions, initial and final, better results were attained by dominant hand. Moreover, after training sessions the dispersion of the results (CV%) within each type of shot put were lower.

Table 1. The best score of six attempts of shot put attained by dominant, right hand (DH), non dominant, the left one (NDH), before the training (term 1) and after its (term2), for habitual and inverse stances. The results (length of shot) are expressed in meters. The load of puts were of 4 kg for subjects F1-F4 and of 5 kg for subjects F5-F7

subject	BM	normal (habitual) stance				inverse (non habitual) stance			
		DH1	DH2	NDH1	NDH2	iDH1	iDH2	iNDH1	iNDH2
F1	52	7.72	8.04	7.25	7.70	8.03	8.45	6.43	7.08
F2	54	7.62	8.05	7.11	7.49	7.70	7.80	6.32	6.91
F3	54	6.45	7.15	6.30	6.74	6.45	7.50	6.37	6.62
F4	54	7.20	7.74	6.78	6.92	7.05	7.70	6.17	6.60
F5	62	6.40	6.90	5.50	6.02	5.80	6.66	5.42	6.03
F6	69	5.55	5.78	5.15	5.42	5.52	5.62	5.01	5.40
F7	78	6.75	7.42	5.70	6.18	6.65	7.45	6.10	6.65
Means ±SD		6.81 ±0.76	7.28 ±0.77	6.26 ±0.83	6.63 ±0.82	6.73 ±0.92	7.29 ±0.92	5.97 ±0.55	6.46 ±0.58

Table 2. Differences between the shot put scores with respect to the terms, hands, and stances (the Wilcoxon test)

factors	comparison of means	differences (meters)	Z function	p values
terms 1 vs 2	DH2 > DH1	0.47	2.37	0.018
	NDH2 > NDH1	0.37	2.37	0.018
	iDH2 > iDH1	0.56	2.37	0.018
	iNDH2 > iNDH1	0.49	2.37	0.018
hand (D) dominant (D) vs. ND non-dominant	DH1 > NDH1	0.55	2.37	0.018
	DH2 > NDH2	0.65	2.37	0.018
	iDH1 > iNDH1	0.76	2.37	0.018
	iDH2 > iNDH2	0.83	2.37	0.018
stances habitual vs. inverse	DH1 vs. iDH1	0.08	0.73	0.463 ns
	DH2 vs. iDH2	-0.01	0.00	1.000 ns
	NDH1 vs. iNDH1	0.29	1.52	0.128 ns
	NDH2 vs. iNDH2	0.17	1.18	0.237 ns

Table 3. Within – subject variability (CV%) of each type of the shot

F	BM	normal (habitual) stance				inverse (non habitual) stance			
		DH1	DH2	NDH1	NDH2	iDH1	iDH2	iNDH1	iNDH2
F1	52	5.8	5.2	6.3	5.7	5.1	4.7	7.4	6.6
F2	54	4.5	3.3	5.5	4.7	5.3	5.1	5.4	4.2
F3	54	2.4	3.5	4.2	3.5	3.4	3.3	5.1	3.8
F4	54	5.2	4.6	6.4	6.2	4.6	4.3	5.8	4.6
F5	62	3.8	2.6	4.1	3.6	4.3	3.5	5.2	3.1
F6	69	6.2	5.4	7.9	6.3	5.7	5.2	4.5	4.1
F7	78	5.8	4.2	6.7	5.8	7.3	5.3	5.6	4.9
X ±SD		4.7 ±1.2	4.5 ±0.9	5.9* ±1.4	5.1 ±1.2	5.1* ±1.2	4.5 ±0.8	5.6* ±0.9	4.5 ±1.1

Mean CV% values significantly ($p < 0.02$) are higher before training period than those after its

Discussion

As was shown, 14 shot put training sessions covering 84 shots (14 x 6=84) for each of four various type of bouts resulted in significant improvement of explosive strength. That change occurred in highly skilled athletes in the middle of training season, when the highest fitness was achieved before the first shot put test. Considering study on results of shot put as a mirror of specific explosive strength it should be stressed some limitation regarding that assumption. Initial velocity of the flying put (V) is an important factors that depended on strength and power [1-3], the second one is the realized angle (α) between the initial trajectory and the ground. The length of a diagonal throw (Z) that represents shot put flight is given by the following formula:

Were H is the altitude over the ground from which a shot starts its flight, while the constant parameter, g, is the acceleration on the ground level (9.81 m/s²).

Unfortunately, the strength of upper body limbs and the angle were not controlled in this study, hence, that may be the reason for an uncertainty regarding contribution each of mentioned factors to the post-training improvement of shot put performance. According to the formula for Z several researchers noted fluctuations of explosive strength realized during shots put over training season among the putters [14-16], but in the field condition mentioned factors are seldom controlled. Although in the theory Z(α) function reaches its maximal value at the angle of 45 degrees, in the practice, such steep slope of the trajectory is not realized by shot putters. The reason is that strength generated by the putter during the bout is

inversely related to the taken angle i.e. it decreases with and increasing angle [17-19]. Thus, each performer has to find his/her optimal angle leading to the best result. For instance among shot putters, gold medalists of Paralympic Games release velocity ranged from 8.30 to 9.96 m/s and 4.58-8.50 m/s, while the angle of shot's trajectory were 27.54-32.47 degrees and 9.02-34.52 degrees in males and females respectively [20]. Lower mean speed of the put (5.3-7.8 m/s) but at similar range of the angles (21.2-34.4 degrees) were demonstrated by non-elite wheelchair putters [21]. Both those parameters were related to sport class and distance of the throws.

As to studies on the parameters of typical boxing punch, speed of thrown punches was examined in boxing together with force peak of punches. Top level British professional heavyweight boxer reached maximal punch speed of 8.9 m/s and force of that punch was of 4097 N. [22]. Later study showed that mean velocity of boxer's hand when punching ranged values of 7.6-11.9 m/s and that variable did not depend on the weight category [23]. Other study showed, that mean maximal straight punch forces gradually decreased among the group of various male boxers of various skills, in elite (4800 N), intermediate (3722 N) and novice boxers (2381 N) for the rare hand, and these scores compared with those for the lead hand were markedly ($p < 0.001$) higher [24]. That comparison showed an important role of punches strength and justifies the exercise with put in boxing. However, it is worth to note, that the shot put scores are related not only to strength of the upper extremities the angle. Terzis showed that also strength of lower body limbs, like maximal back squat significantly correlated with shot put performance [25], and counter jumping or sprinting (20m) undergone directly prior to shot put test, as a warm-up, significantly improved shot put test consisted of the 3 repetitions [26]. That phenomenon occurs due to neuromuscular activation of the lower body limbs, that are play a key role in rotational style and power position in shot-put athletes.

Among examined female boxers the mean relative improvement of shot put performance (by 7.2%) was 2-fold higher than that recorded in the Lithuanian performers [13] despite of shorter training period and very little contribution of strength exercises to the overall training loads during the period. On the other side, daily exercises with the put and receiving information regarding the distance after the each attempt facilitated each of examined subject to choose the individual optimal angle of the throws and to improve the coordination of movements of the whole body during throws. Thus, comparing various lengths of training period, type of utilized exercises and final extent of shot improvement reported by us and by the others [13], we may speculate the high contribution of the technique to the obtained results in this study. Lack of the influence of the stances on the performance by dominant or non dominant hand resulted in specific technique of throws. As mentioned, for normal stance and right-handed boxers their non dominant and dominant hands were directed front and back respectively. Normally, setting hands to feet is compatible, however, for inverse stances, when performing the

throw by the front (right) hand, counter-rotational style has been utilized. In that case so-called front hand executed the throw not from front – but from reversed position and that motion occurred simultaneously with the torso rotation of the same direction. The same counter-rotational technique was used when throwing by front (left) from the normal stance. Thus, for the both, non dominant or dominant hand, from the both stances the same forward movement of the active front hand- the elbow muscles extension- was synchronized with rotations of T-S. Hence, in fact, for each type of the stance there were not front hand but only reversed one. That was the reason for lack of stance-related differences in the physical performances. As mentioned, the aim of that trainings with put was to improve the strength of punches thrown from normal and inverse stances. That schedule was taken, assuming the fact, that changes in the stances by a contestant during a fight may bring her/him beneficial effects. This expectation based on reported observations, that left-handed boxers have a predominance over right-handed opponents [27]. On the other side when a right-handed boxer takes inverse stances, his/her straight blows thrown from reversed, non dominant (left) hand will be of somewhat lower power, compared to that performed by right hand from normal stances. These hand-related differences in an explosive power expressed by shot put for the both upper body limbs were shown among the males [13] and in both sexes [28].

The question, about how much better might be shot put performance due to technique of rotation and counter-rotation of T-S is to be determined in a further study. Considering the fact, that the power generated by the extending elbow joint muscles is additionally magnified by released an elastic energy stored in muscle-tendon complex due to backward rotation of T-S and released during the opposite rotation, we may expect that marked the effect may exist. Some other studies also support this expectation. The blowers (cricket-players) with greater shoulder counter-rotation demonstrated higher elbow flexion and subsequently its extension [29], and the counter-movement condition strongly enhanced maximal elbow joint power of extension due primarily to the accumulation of elastic energy and its utilization during the extension [30].

Our study revealed significant improvement of reproducibility of the performance within each of four type of bout consisted of 6 repetitions. That change occurred probably due to stabilization of the realized angle and/or the better coordination of the motions, i.e. harmonization of T-S rotations and arm extension. One may assume, that the above factors contributed to the better shot put performance after trainings, independently from the improvement of explosive strength, that unfortunately was not examined by the other methods.

Summing up, shot put training may be include in that part of boxing drills, which allows safely to develop and to examine maximal punching strength without risk of a hand injury. Obviously, the exercises with put cannot replace fully those boxing drills which are oriented to improvement of time response. Hence,, after limitation of bouts with maximal hitting the heavy bag, another exercise developing psycho-motor

ability has to be incorporated into the boxing training for instance mitts exercises. Moreover, when planning any innovations in the traditional boxing training schedule it is recommended to control the training effects by means of the various standardized and specific physical tests, as was described by the others [13].

Conclusion

Daily shot put exercises performed throughout 2-week period significantly improved the performance of those bouts in highly skilled female boxers.

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