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 be 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 carrier 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
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 series of six maximal shot puts performed every day, by left and right hand with taking both stances, habitual and inverse one.

Put performance for evaluation the effects of training mesocycle 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 were performed 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 excluding series of maximal shot puts performed every day, by left and right hand with both stances, habitual and inverse one.
Discussion

As was shown, 14 shot put training sessions covering 84 shots (14 x 6=84) for each of four various type of bouts result-
ed 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 be-
fore 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 de-
pended 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:

\[ Z = \frac{V^2 \sin 2\alpha}{g} \]

Were H is the altitude over the ground from which a shot
starts its flight, while the constant parameter, g, is the accele-
ration 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 men-
tioned factors to the post-training improvement of shot put
performance. According to the formula for Z several resear-
chers 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 rea-
son is that strength generated by the putter during the bout is

| 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 | DH1 | DH2 | NDH1 | NDH2 |
| 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 | 6.76 | 6.92 | 7.05 | 7.70 | 6.17 | 6.50 |
| 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 | 68 | 6.75 | 7.42 | 5.70 | 6.18 | 6.65 | 7.45 | 6.10 | 6.65 |
| Means | 6.81 | 6.72 | 6.26 | 6.63 | 6.73 | 7.29 | 5.97 | 6.46 |
| ±SD | ±0.76 | ±0.77 | ±0.83 | ±0.92 | ±0.92 | ±0.92 | ±0.55 | ±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 (medians) | Z function | p values |
| terms 1 vs 2 | DH1 > DH2 | 0.47 | 2.37 | 0.018 |
| NDH1 > NDH2 | 0.37 | 2.37 | 0.018 |
| DH1 > NDH1 | 0.49 | 2.37 | 0.018 |
| NDH1 > NDH2 | 0.55 | 2.37 | 0.018 |
| hand (D) dominant (D) vs. ND non-dominant | DH1 > NDH1 | 0.49 | 2.37 | 0.018 |
| DH1 > NDH2 | 0.65 | 2.37 | 0.018 |
| DH2 > NDH1 | 0.76 | 2.37 | 0.018 |
| DH2 > NDH2 | 0.83 | 2.37 | 0.018 |
| stances habitual vs. inverse | DH1 vs. DH2 | 0.08 | 0.73 | 0.463 ns |
| DH2 vs. NDH1 | -0.01 | 0.00 | 1.000 ns |
| NDH1 vs. NDH2 | 0.29 | 1.52 | 0.128 ns |
| NDH2 vs. NDH2 | 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 | DH1 | DH2 | NDH1 | NDH2 |
| 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 | 5.7 | 5.8 | 7.3 | 5.3 | 5.6 | 4.9 |
| X | 4.7 | 4.5 | 5.9* | 5.1 | 5.1* | 4.5 | 5.6* | 4.5 |
| ±SD | ±1.2 | ±0.9 | ±1.4 | ±1.2 | ±1.2 | ±0.8 | ±0.9 | ±1.1 |

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

One should assume, that the above factors contributed to the better shot put performance after trainings, 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 join 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, a few 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 mits 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.

References


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