The shot put performance as a marker of explosive strength in polish amateur boxers. A pilot study

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B Data Collection
C Statistical Analysis
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Abstract

Background and Study Aim: The shot put performance was utilized as an useful field-test of specific explosive strength in boxers. It was assumed, that type of motion undergoing during the shot put is similar to that during execution of punch. The relationships among length of the throws, body mass and blood testosterone were examined in female and male boxers.

Material/Methods: Polish right-handed boxers, seven females and seven males were subjected to this study. Capillary blood was sampled for assessment serum testosterone, prior to the test. After warm- up, technical instruction how to perform the test, and after some preliminary attempts, each subject performed seven shot puts by right and seven ones by left hand, involving his/her maximal physical ability.

Results: There were no clear relationship between absolute results and body mass in females, but relative results (length of throw distance/body mass) attained by right or left hand strongly declined with body mass. Among males boxers better absolute outcomes were recorded with body mass. Moreover, the males demonstrated better results than did females. As predicted, shot put results were significantly better when performed by right hands. The explosive strength did not depend on testosterone levels within each of the examined group.

Conclusions: Execution of seven successive shot puts seems to be useful field test for qualitative rating of strength of punch in boxers.

Key words: boxing • gender • shot put • punching • explosive strength

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Background

The main physical requirement for well skilled boxers is high level of explosive strength generated by left and right arm during execution of punches. For that reason measurements of impact force of blows using special apparatus with appropriate equipment have high diagnostic value. The earliest studies focused on measurements of peak of impact force and/or acceleration, that was performed by means instrumented target suspended as a ballistic pendulum supplied with accelerometers or boxing dynamometer. Using that tool Atha [1] examined world ranked heavy weight boxer (Frank Bruno) and revealed his peak impact force of 4096 N, while acceleration peak of the 7-kg target was of 53 g. The later study conducted by Smith et al.[2] showed skill- and body mass- related differences in punch performance. The authors reported higher mean peak load in elite boxers (4800±601 N) compared with that in intermediate ones (3722±375 N). Walilko et al also found significant correlation (+0.539, $p<0.05$) between body weight and punch force [3]. Since mentioned results may be obtained due to advanced methods which are hard available for boxers on a training camps at field conditions, therefore, more easy and simple methods to monitor explosive force are needed. We

Table 1. The characteristics of female boxers (F1-F7) and their outcomes of shot put by left (LH) and right hand (RH).

Femal	BM (kg)	T	RH (cm)	LH (cm)	RH (cm/kg)	LH (cm/kg)	RH/LH (p values)	CV% R/L
F1	49	1.6	683±45 670–710	594±48 540–680	14.0±0.9	12.2±1.0	0.05	6.6/8.2
F2	54	2.7	701±47 630–763	596±33 540–634	13.0±0.9	11.0±0.6	0.01	6.7/5.5
F3	59	2.9	655±43 610–718	578±47 496–622	11.1±0.7	9.8±0.8	0.05	6.6/8.1
F4	63	2.6	668±25 630–696	598±26 570–646	10.6±0.4	9.5±0.4	0.001	3.7/4.3
F5	67	2.3	662±38 626–714	611±10 595–624	9.9±0.6	9.1±0.1	0.01	5.7/1.7
F6	76	2.8	719±20* 685–745	623±23 580=654	9.5±0.3	8.2±0.3	0.0001	2.8/3.7
F7	86	2.6	668±32 615–705	537±35* 470–570	7.8±0.4	6.2±0.4	0.005	4.8/6.5
X SD	64.8 12.8	2.5 0.4	680 38	592 41	10.8 2.0	9.4 1.9	0.00000	5.6/6.9

* p<0.05, the means puts by RH: F6 differ from F3,F4, F5, the means puts by LH: F7 differ from F5 and F6.

assume that performance of the shot put may be considered as a mirror of explosive strength realized during maximal impact punch, since motion of arm extension during the put throwing is somewhat similar to boxing blow. Our assumption is bases on the investigations by authors, who utilized studies on shot put performance for evaluation power levels realized by upper limbs, especially for examinations of activation of triceps brachii among various athletes, including shot-putters [4–6]. It was found, that shot put performance [5,7,8], and performance of medicine ball throw [9] being a reflex of a sport-specific dynamic explosiveness were related to the other strength-power parameters of upper and lower extremities. Some author suggest association between the level of explosive strength and serum testosterone concentration. That topic has been examined widely, and the relationships among these variables has been found only in male athletes, whose sports activity were oriented on endurance or strength development. Bosco [10] reported positive correlation between basal serum T and the both efforts: counter movement jump (vertical jump performance) and 30 m running test, but negative one between T and cortisol levels with endurance capacity (12 min running test). Likewise, among strength trained athletes changes in muscle cross-sectional area following long-lasting training were related to the changes in resting serum T [11]. The purpose of this pilot study was to examine reproducibility of shot put performance during seven successive trails undergone by female and male boxers and to estimation of usefulness of that boats for rating explosive strength generated by upper body.

Material and Methods

Polish right-handed boxers of national level, seven females (F1-F7, aged 20.4–31.0 yrs) and six males (M1-M7, aged 21.4–26.8 yrs) were enrolled to this study. They performed a series of maximal shot puts from standing position, seven shot by left and seven by right hand in a randomized order. An extension action of arm was simultaneously synchronized with small trunk rotation by c.a. 45 radians to enhanced an effect of performance. All subjects was earlier informed, that according to the kinematics lows, the maximal flight distance of a diagonal throw with the established initial shot velocity is attained when angle between ground and the direction of the beginning phase of the flight is of 45 radians. Before the test, females and males were familiarized, warmed-up and underwent some puts, that allowed them to establish the optimal trajectory of flight. Directly before first attempt capillary blood was sampled for determination of serum testosterone levels, with using DRG-GERMANY kit. Statistical tests: Mann-Whitney U test for detections of differences within each subject between his/her mean personal results attained by left and right hand, and Kruskal-Wallis test for comparison between-subject differences.

Results

Results of obtained results are displayed in Table 1 and 2. Table 1 presents individual values of body mass values (BM), serum testosterone levels (T in nmoL) and means personal data ±standards deviations (SD) and coefficients of variation-CV% (SD/X*100%) calculated

Table 2. The characteristics of male boxers (M1-M7) and their outcomes of shot put by left (LH) and right hand (RH).

M	BM (kg)	T	R H (cm)	LH (cm)	R H (cm/kg)	L H (cm/kg)	RH/LH (p values)	CV% RH/LH
M1	51	13.4	640±45 582–695	588±26 543–624	12.5±1.0	11.5±0.6	0.05	7.0/4.5
M2	54	11.8	774±28 742–805	622±37 598–696	14.3±0.5	11.5±0.7	0.00001	3.6/5.9
M3	68	19.4	930±25 896–973	805±39 755–845	13.7±0.4	11.8±0.6	0.0001	2.7/4.8
M4	71	17.0	941±24 905–974	797±36 733–822	13.3±0.3	11.2±0.5	0.0001	2.6/4.5
M5	83	6.7	998±37* 932–1034	800±43 728–864	12.0±0.4	9.6±0.5	0.00001	3.7/5.4
M6	83	20.0	1016±21* 995–1052	837±15 818–856	12.2±0.3	10.1±0.2	0.00001	2.1/1.8
M7	96	19.0	1088±60* 1006–1188	865±53 799–932	11.3±0.6	9.0±0.6	0.0001	5.5/6.2
X SD	72.3 16.3	15.3 4.9	924 68	771 55	13.0 0.7	10.9 0.9	0.00000	7.3/7.1

*p<0.05 the means puts by RH: M7, M6, M5 differ from M1, M2, M3. the means puts by LH: M3-M7 differ from M1, M2.

from seven successive attempts of shot put results expressed as absolute (cm) and relative (cm/body mass) outcomes undergone by right hand (RH) and left hand (LH) recorded in seven female boxers. The similar data obtained from males are presented in Table 2.

Pre-exercise plasma testosterone levels were in female boxers within physiological expected values (0.9–4.4 nmol/L), whereas in males one subject demonstrated the levels below lower limit for healthy males which amounts 8.3 nmol/l. Among females between-subject differentiation regarding individual mean absolute results of shot pout performance was not high. These results was not related to body mass as was shown in Table1. In a consequence relative (absolute results/body mass) results of performance by left and right hand markedly and progressively dropped with body mass. Relationships among relative shot put performances and body masses among females are describes by linear regressions as follows: Right hand performance (cm/body mass)=21.01–0.157*body mass (R=–0.9637). Left hand performance (cm/body mass)=19.06–0.149*body mass (R=–0.9852). Likewise, in the group of six males, with excluded M1, linear regressions describing relations between relative performance and body mass are as follows: Right hand performance (cm/body mass) =18.71–0.077*body mass (R=–0.911),

Left hand performance (cm/body mass) =15.87–0.071*body mass (R=–0.898). It is worth to notice, that in contrast to lack of relationships between females body mass and performance in male boxers specific explosive strength increased with body mass. Moreover sex related differences in absolute the performance appeared mainly among boxers of heavier mass, whereas differences between males and females whose body mass were within the range of 49–54 kg were not as high as among heavier athletes. For instance in weight category of 54 kg, F2 demonstrated results 93% of these by M2, but F7 results (body mass 86 kg) amounted 67% of those attained by M5 (83 kg). Absolute and relative mean personal results of shot put performed by right and left hand showed in both sexes meaningful asymmetry, as all the subject were right-handed. Reproducibility of performance of successive attempts expressed by CV% did not excided 10%.

Discussion

Despite familiarization and warm-up which were performed prior the test, the best mean puts were attained at 4th and 5th attempts, while the worst performance was at 1st attempt. These relative values for right and left hand amounted 90 and 92% that of the best trial. Deliberating obtained results it is worth to stress, that range Z(m) of a diagonal throw of shot is given by the following formula:

$$Z = \frac{V^2 \sin 2\alpha}{2g} + \frac{V \cos\alpha \sqrt{V^2 \sin^2 \alpha + 2Hg}}{g}$$

where V(m) is an initial velocity of shot, α is an angle between the ground and initial direction of flight, and H(m) is an altitude over the ground from which a shot starts its flight and g is Earth' gravitational acceleration (9.81 m/s*s). Factor H had minor influence on the shot flight in our experiment since examined females were not very vary by their height (161–177 cm) despite marked differences of their body mass. Based on a series of experimental throws

undergone during warm-up, examined boxers choose the optimal angle, that produced the greatest flight distance. In our study during consecutive trials realized angle was not measured, however it was less than that of 45 radians, which theoretically produces the longest distance, when initial velocity is stable. It should be stressed, that the dependency between distance of athletic throws or flight and realized angle was tested comprehensively by others. It was found inversely relationship between released angles and real initial speed of flight for the shot [12,13] discuss [14] and for long jumpers [15], hence, these athletes take-off individual and optimal angle to achieve the best results. Our study on female boxers provided unexpected results, i.e. lack of clear relationship between distance of throws and body weights. However examined by us subjects of heavier body mass were at the first glance of higher percentage of body fat tissue, thus, their body weights did not reflected their lean body masses. Unfortunately, we ignored in our experiment an effect of body composition on shot put performance, but the other authors found correlation between free-fat mass and shot put performance from the power position (but not for rotational style) (r=0.76*) at pre-season, and (r=0.66*) at competition period [16]. There is also other reason for lack of expected relationships between body mass and shot put performance among the females. Explosive strength represents possibility to develop maximal force over very, very short time-duration, thus, it may be named as dynamic strength. That parameter is responsible for performance of throwing of mass like discus, javelin or put, as well as fast lifting of weight, that required simultaneously both physical features, strength and velocity, that is determined as power output. Throwing performance, seems to be more dependent on rate of force development (dynamic strength) than on maximal static strength (lack of motion) as dynamic peak of strength is not related to static peak of strength against light loads [17].

The present study provided at the first glance unexpected results. Explosive strength was poorly-if ever-related to body mass in females but well related in males. It seems, that the reason for that was likely sex-specific body components, percentage of body fat and free fat mass, differentiating examined females and males. At the first glace in heavier females percentage of fat tissue was higher, i.e. more contributed to overall body mass. As only lean body mass (the active tissue) is responsible for strength and power [18,19] and correlated with shot put performance [20], hard to expect close relationships between explosive strength and body mass among athletes of various body mass components. The other reason for sex-differences in explosive strength is androgenic status in blood. Cardinalle [21] pays attention to sex-related differences in blood testosterone level as a meaningful factor discriminating explosive strength between males and females. He reported, that among athletes undergoing vertical jump test, female athletes demonstrated performance on average 86.3% of that by males. Likewise, among judokas undergoing 30s Wingate test, the mean relative peak of power output (watt/kg) among females amounted to 86% of that recorded in males [22]. Moreover, mean relative power peak (W/ body free fat mass) was higher in male kayakers, whose fat percentage was lower than that recorded in their female counterparts [23]. Similar sex-related differences in explosive strength were recorded among our boxers. Taking into account groups of seven females (F1-F7) and 5 males (M1-M5) having comparable mean body mass (female group 64.8 and male group 65.4 kg), we found females shot put performance by right and left hand as 79 and 83% of those presented in male group. Performance of shot put strongly depends on style of put. The most effective one is rotational put when the left arm (right handed putters) vigorously swing immediately before the right arm extension [24]. As mentioned, our subjects were not allow to use that kind of motion, and rage of small trunk rotation was comparable to that during punch execution by right hand. Thus, the best relative trial by right hand of elite male boxer (M7, 12.4 cm/kg) was worse than that demonstrated by four sub-elite shot putters using rotational shot put (16.3–14.1 cm/kg) [24]. The extents of observed by us mean asymmetries between right and left hand ability in males (18%) and females (15%) were higher than those regarding hand grips in elite male Mexican boxers of lightweight, middleweight and heavyweight divisions (4.3–5.9%), who in addition demonstrated strong relationships body mass-hand grip [25]. It seems that higher asymmetry between explosive strength of RH and LH recorded in our study may be results in worse motor coordination of left arm (non-dominant) during shot put.

The level of reproducibility of the trials (CV%) suggests somewhat higher number of the attempts to obtain more accuracy of explosive strength rating. That variation of the performance may be result in two independent and uncontrolled in our study factors, various force development and flight speed at the beginning, and various angles between the beginning of the flight and ground. The estimation of contribution of the second one to attained distance needs recording of the trajectory on video. Without these data, examination of shot put outcomes meet criteria only for qualitative estimation of blow strength or its energy in boxing. Moreover, it is worth to put the question, whether the same weight of shot (5 kg) is proper for determination of real explosive strength among athletes of various body mass.

Conclusions

Final conclusions have to be formulate carefully because of small samples. The level of reproducibility (CV%) for

seven successive shot puts, performed by left and right hand seems to be insufficient for accurate, quantitative determination of specific explosive strength. In female boxers specific relative explosive strength strongly declined with body mass.

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