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Does the use of a light shot put modify the throwing pattern of elite athletes?

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Abstract

The aim of this study is to analyse the influence of the weight mass (6 vs 7.26 kg) in kinematics parameters on an expert throwing shot put in rotation, in order to estimate the influence of using a lighter weight to minimise the arm thrower's risk of injury or during recovery training. This study was done on a sample selection of three elite throwers (best performance 16.51 ± 0,81m) from the French national team, who performed three throws with a 6 Kg weight mass and three others with a 7.26 Kg weight mass. Motion analysis of each throw were recorded using an optoelectronic system (Vicon612) composed of six infrared camcorders and a 3-D modelling of the throwing movement was processed according to the Dapena method. The thrower and weight center of mass velocities were computed for each throwing phase. Friedman Anova analysis showed no significant difference on the subject center of mass and weight velocities (respectively $p = 0.86$ and $p = 0.45$) between both weight mass conditions. No significant shot put mass effect, ($p = 0.86$) on the phases duration in both conditions of weight (6 vs 7.2 kg), were observed. These results suggest that a weight mass lower than 27 % could be used for elite athletes training without a change in velocity of the motion throw. This could be used in order to narrow musculo-squeletal overwork and injury during intensive phases of training and/or to quickly return to specific throwing motion during recovery of the shoulder complex. This should allow for the use of a lighter discus during high level training without kinematical alteration of throwing.

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Key words: Shot put, Kinematics, Modelling, Throwing technique, Prevention.

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1. Introduction

Shot put is a complex movement that associates segment's translation and rotation (Ariel, 1973; Zatsiorsky et al., 1981; Lanka, 2000; McCoy and Gregor, 1984; Hubbard, 1989). The goal is to release the shot put with maximum forward velocity at an angle of approximately forty degrees (Bashian et al., 1982; Hubbard et al., 2001; Linthorne, 2001; Bartonietz, 1996). Nowadays, most of the high level competitors use the spin style whose main purposes is to reach a high rotational speed of the body and to transfer the energy into the shot put, Linthorne (2001). As in discus studies, detailed analysis of the shot put throwing in rotation is facilitated by subdividing the movement into five phases:

- Preparation, double support phase starting from the change in shot put direction at the end of its backward swing and ending when the right foot breaks contact (Δt_{1da}).
- Entry, single support phase which finishes with the left foot breaking contact (Δt_{1sa}).
- Airborne, which finishes with the right foot re-contacting (Δt_s).
- Transition, single support phase which ends as the left foot lands (Δt_{2sa}).
- Delivery, which starts as double support phase and which ends at release of the shot put (Δt_{2da}).

Each phase is separated by "key moments" mostly related to foot contact. Even if the release conditions have been habitually recorded, few studies have focused on the thrower's co-ordination (McCoy and Gregor, 1984; Linthorne, 2001). In order to perform the shot put, the thrower must control a complex motion that is executed in the limited space of the shot put area in agreement with the IAAF rules (IAAF 2011). The best throwers are able to improve their rotation velocity during the delivery phase (McCoy and Gregor, 1984 ; Linthorne, 2001). However, this velocity improvement when associated with the shot put mass can increase shoulders injuries during competition. Edouard et al. (2010) showed that 75% of throwers presented one or more injuries of the throwing arm during their careers. The shoulder was the most commonly injured body part (70%) (Edouard et al., 2010). In order to limit the injuryrisk and/or for faster recovery, coaches (Cappos, 2014; Wyatt, 2003) recommended training using a lighter shot put (6 vs 7.26 kg). Dinu et al. (2008) have shown similar results in the discus throws. Presently, few studies report the benefits of performing while using a lighter shot put (Judge et al., 2013).

2. Methods

The experiment took place in an indoor hall at the Institut National du Sport, de l'Expertise et de la Performance (Paris, France). Three male subject volunteers (21.33 ± 1.53 years, 128.57 ± 21.83 kg, 190 ± 6 cm, best performance : 16.51 ± 0.81 m) participated in this study. All subjects were high level shot putters from the French national team. All subjects were asked to perform a series of 20 throws using both 6 vs 7.26 kg shot puts, in random order. The throwing distance was measured after each shot put. For each subject, only the three best shot puts (longest distance) in both weight categories were studied. In total 18 throws were studied. Kinematic data were collected by Vicon612 systems (Vicon Motion systems, Oxford, UK). The optoelectronic system (Vicon) consisted of six infrared camcorders. A static calibration around the throwing area was done. A dynamic calibration was performed using a 390 mm stick with two markers moving in the throwing area. The sampling frequency of the Vicon system was 200 Hz. For this experiment, 17 reflective markers were attached on the joints of the athlete's bodies. Reflexive markers were fixed on the head vertex, right and left acromions, lateral humeral epicondyles, ulnar styloids, second metacarpal heads, superior iliac spines, fibula heads, lateral malleolus and second toe tips. The subject's center of mass was computed by the markers' trajectories made by the subject and anthropometric data according to De Leva (1996). In order to determine velocity of the reflective markers, numerical derivation of the kinematics data was performed using the moving average rule. Thrower and weight centre of mass velocities were computed for each throwing phase. Data was collected starting from the preparation stage to the delivery stage. A Friedman Anova was used to compare the significant difference between the velocities and the time of each phase measured between both mass shot puts (6 vs 7.2 kg).

3. Results

The Friedman Anova analysis showed no significant shot put mass effect (p = 0.45) on velocities during the different phases of throw in both conditions of weight (6 vs 7.26 kg). In addition, there was no significant shot put mass effect (p = 0.86) on the subject center of mass velocities (Table 2) during the different phases of throw in both conditions of weight (6 vs 7.26 kg). Likewise, there was no significant shot put mass effect (p = 0.86) on the phases duration in the both conditions of weight (6 vs 7.2 kg).

The kinetics of shot put velocity (6 vs 7.26 kg) during the different phases of the throw is presented on Figure 1 and Table 1, below. After an increasing shot put velocity during the preparation phase, noticeably there is a relative plateau in the shot put velocity during the entry and airborne phases. Velocity began to increase again at the end of transition phase and during delivery. The shot put velocity is maximal at release. The delivery phase has been reported as responsible for 62 % of the release speed of the shot put.

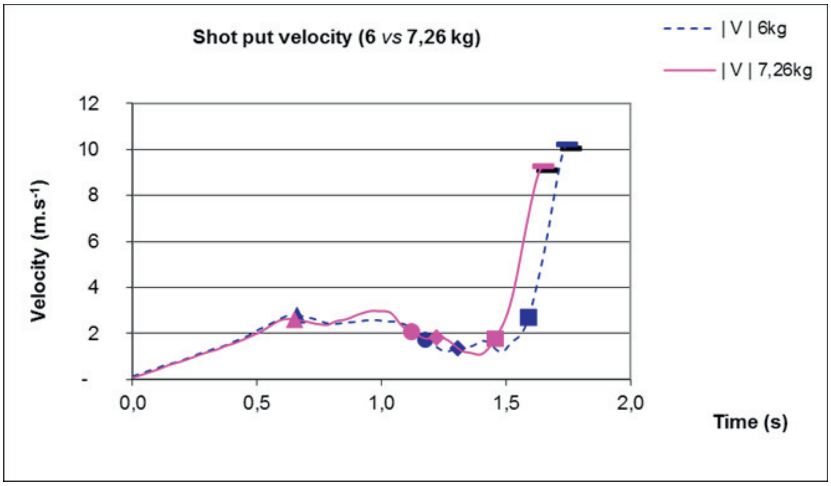

Fig. 1. Comparison of shot put velocity for the two conditions of mass 6 vs 7.2 kg.

Table 1. Kinematics' parameters of shot put.

Kinematics parameters	Time instant & phases	Mean (± SD) Shot put 6 kg	Mean (± SD) Shot put 7.26 kg
Vcm ($m.s^{-1}$)	t1da	0,81 ± 0,13	0,81 ± 0,15
	t1sa	2,16 ± 0,17	2,19 ± 0,16
	ts	2,11 ± 0,21	2,14 ± 0,23
	t2sa	1,80 ± 0,21	1,83 ± 0,20
	t2da	1,47 ± 0,39	1,43 ± 0,36

Table 2. Kinematics' parameters of thrower's center of mass.

Kinematics parameters	Time instant & phases	Mean (± SD) Shot put 6 kg		Mean (± SD) Shot put 7.26 kg	
Vsp ($m.s^{-1}$)	t1da	**2,67**	± *0,20*	**2,85**	± *0,22*
	t1sa	**1,84**	± *0,13*	**1,89**	± *0,27*
	ts	**1,43**	± *0,11*	**1,53**	± *0,28*
	t2sa	**2,79**	± *0,22*	**2,59**	± *0,95*
	t2da	**9,83**	± *0,35*	**9,30**	± *0,21*

4. Discussion

The result of this study shows that the subject center of mass and shot put velocities are not disrupted by the weight shot put mass difference (6 vs 7.26 kg) during each phase of the throw. The limitation of this study is related to the relatively small number of subjects studied. However, these athletes are a good representative sample of the best European elite population.

The results demonstrate that the shot put velocities were not influenced by the weight shot put mass difference (6 vs 7.26 kg) during each phase of the throw. The mean shot put velocities are in agreement with the Dapena (1993) results. Futhermore, the results of this study are consistent with previous studies observed on discus thrower (Schluter and Nixdorf, 1984; Schöllhorn, 1989; Dinu et al. 2003, 2008) with different discus weight (1.7 vs 2 kg). Therefore, in order to improve the recovery of the technical level of athletes after injury, it would be beneficial to use a light weight during the training. This could reduce the risk of a new injury related to mechanical load and musculoskeletal stress. According to Ohberg and Alfredson (2004), sub maximal exercise seems to be associated with a more normal tendon structure and no remaining neovascularisation. Training with a light weight shot put would be beneficial for the tendon of the shoulder complex. This could also help prevent shoulder tendon and ligament injuries.

According to the discus throw analysis, it has been observed that the shot put velocity tends to increase at release when athletes used light weight shot puts. This increasing velocity occurred especially during the delivery phase when the athlete threw the light weight shot put (6 kg). This increasing velocity observed during the delivery phase could improve the shot put performance. This tendency is in agreement with previous coaches' recommendations (Cappos, 2014; Wyatt, 2003). However, this tendency has no statistical significant effect on the shot put velocities. Using a similar rotation techniques, Lindsay (1991) and Knicker (1990) observed comparable increasing velocities during the delivery phase in discus throwing analysis. In contrast with the shot put velocities, the subject's center of mass velocities seem much closer during each phase of the throwing motion for both weight shot puts mass. This result is in agreement with previous studies observed on center of mass discus thrower (Dinu et al., 2008).

5. Conclusion

This study showed that the use of a lighter shot put did not influence the shot put and center of mass velocities and phases' durations on elite throwing motion. These results suggest that a weight mass lower than 27 % could be used for elite athlete training without velocities change of the throw's motion. Moreover, this could be used in order to narrow musculo-squeletal overwork and injury during intensive phases of training. It could also be used in order to improve the return to specific throwing motion during recovery of the shoulder complex. Consequently, a lighter discus maybe used for high level training without affecting the kinematical alteration of throwing.

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