THE WEIGHT OF PROJECTILE AND THROW DISTANCE

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INTRODUCTION: The throw distance depends on initial speed, elevation angle, weight of projectile and its aerodynamic properties. In terms of biomechanics, the initial speed is dependant on the weight of projectile, force capacity of the subject and the throwing technique. When addressing motion equation of oblique throw inclusive of air resistance and projectile weight we get an equation expressing maximal throwing distance X_m (Packel & Yuen, 2004; De Mestre, 1990):

$$X_m = \frac{v_0^2 \sin 2\alpha}{g}\left(1 - 2\sqrt{2}\,\frac{k v_0^3}{3mg^2}\right)$$

The aim of the study is to analyze the influence of projectile weight on throw distance under stabilized aerodynamic parameters.

METHODS: A group of men (n=85, BH ± 0.08 m, BW 76.52 ± 10.37 kg) and women (n=70, BH 1.69 ± 0.07, BW 58.81 ± 6.04 kg) performed a set of throws under the condition of reaching maximal distance with projectiles of varying weight (tennis balls with varying filling, weight: 60, 120, 170, 185, 220, 286, 345 g). The ascertained final score corresponded with the highest distance from two trials (coefficient reliability r_{tt} = 0.82-0.95). By means of 2D kinematics, analyses (SIMI) the initial speed of throw and elevation angle was evaluated (not the subject matter of this study). STATISTICA 6 (one-way analysis of variance, correlation analysis, tests of normality data distribution) was used.

RESULTS AND DISCUSSION: The relation between projectile weight and throw distance is illustrated in Table 1. There is an obvious non-linear relation between two quantities, whereby increasing projectile weight causes increase in throw distance and in the event of crossing a certain weight threshold, it begins to shorten. Statistical analysis confirms significant differences between partial throw lengths and approximately defines the limits for optimal weight. The trend of dependency among men and women was alike, whereas the shape of curve differs slightly. Key factors influencing the ascertained tendency include force of air resistance for low weight and muscle force capacity of the individual in case of higher weight.

Table 1 Relation between projectile weight and throw distance

		Ball weight (g):	60	120	170	185	220	286	345
Distance (m)	Men	Mean	39.29	46.88	48.14	48.11	47.42	43.93	41.30
		S.D.	6.88	7.58	8.11	8.58	8.85	8.66	8.09
	Women	Mean	24.13	28.05	27.77	27.43	26.87	25.83	24.00
		S.D.	4.89	5.98	5.76	6.00	5.34	5.81	5.20

CONCLUSION: In both groups, the research validates the existence of optimal weight fields of thrown projectile in relationship to throw distance. In terms of effective utilisation of force capacity of an individual and further throwing practice, it is necessary to set optimal weight limits for projectile per individual.

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INFLUENCE OF BODY WEIGHT ON PULLING FORCE IN HAMMER THROW

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KEY WORDS: hammer throw, body weight, pulling force.

INTRODUCTION: In hammer throw it can be considered that the body weight affects the throwing distance because the muscle volume is directly proportional to the body weight. The pulling force of the hammer may also be affected by the body weight. The purpose of this study was to investigate the influence of the body weight on the pulling force during throwing motion in hammer throw.

METHOD: Throwing motions of 2 elite hammer throwers were recorded by 2 synchronized high-speed video cameras (200 fps) in two international athletic meets. Three-dimensional co-ordinates of body segments and hammer head were obtained with DLT techniques (Abdel-Aziz and Karara, 1971). Initial conditions at release and maximum pulling force acting on hammer head during throwing motion were calculated.

RESULTS: Throwing distance, initial conditions at release and maximum pulling force and body weight of the throwers are shown in Table 1. Throwing distance and initial conditions were similar for the two throwers. However, maximum pulling forces per body weight were quite different.

Table 1 Initial conditions, maximum force and body weight

Subject	Result (m)	Initial Velocity (m/s)	Release angle (deg)	Height (m)	Max. Pull Force (kgw)	Max. Pull Force/Weight (kgw/kg)	Weight (kg)
A	76.37	28.4	40.0	1.46	324	3.60	90
B	76.67	28.9	38.3	1.84	307	2.74	112

DISCUSSION: The hammer throwing motion can be compared to two-body problem in the physics between a thrower's body and a hammer head. Therefore, it can be considered that body and hammer head rotate each other around the common center of mass of these two bodies. In this study, the body weight of subject B was larger than that of subject A about 24%. Then radius of rotation from the common center of gravity to hammer head in subject B was longer than in subject A. As the velocity of the hammer head at release were almost the same in two throwers, subject A's pulling force was larger than subject B's one because the centrifugal force (= the pulling force) was inversely proportional to the radius of rotation.

CONCLUSION: This study identified the influence of body weight on pulling force during the hammer throwing motion. It was concluded that the thrower with smaller body weight had a disadvantage, from the mechanical viewpoints as well as muscle volume.

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