TECHNIQUE COMPARISON OF MALE AND FEMALE HAMMER THROWERS

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Distinct anthropometric differences occur between the sexes throwing the hammer that affect technique. No literature statistically compares the differences between male and female hammer throwers. The aim of this study was to determine the hammer throwing technique differences occurring between genders. The performances of 16 male and female throwers at the 2003 World Athletic Final and 13 male and female throwers from the 2003 USA Track and Field Nationals were examined. The best throw of each athlete was digitized and analyzed using the Peak Motus 8.2 motion analysis system. Results revealed that athlete mass, athlete height, velocity at release, timing components, and centripetal force were different between sexes.

KEY WORDS: hammer throw technique, sex.

INTRODUCTION: Comparisons are made between performance levels based upon sex (Alexander, Linder, & Whalen, 1996; Baronietz & Borgstom, 1995; Ransdell & Well, 1999). Each sex has characteristics contributing to success within their particular sport or event (Ransdell & Well, 1999, Alexander, 1996). Distinct anthropometric differences occur between the sexes throwing the hammer that likely affect optimal technique. The most visually noticeable differences are in body height and mass. Male hammer throwers are typically taller and have more mass than their female counterparts (J.G. Hay, 1993). A difference in implement mass affects the amount of force needed to overcome inertia and the athlete's ability to balance against centripetal forces (J.G. Hay, 1993). With the men's hammer being proportionally more massive than women's relative to body mass differences (7.26 kg compared the women's 4 kg) leads to different requirements for overcoming greater inertia and centrifugal forces (J.G. Hay, 1993; I.A.A.F., 2006). Women are quicker overall at the start of the throw due to less body mass, shorter stature, and less massive implement (Baronietz, Barclay, & Gathercole, 1997). The location of the center of mass of the thrower-hammer system will be different between sexes due to different body weights and implement weights. Center of mass location for the thrower is different between sexes due to differences in weight and mass distribution (J. G. Hay & Yu, 1995; Knudson, 2003). Location of the center of mass of the hammer-thrower system will also be different due to positions utilized by the sexes throughout the throw. Women are more upright during the throw due to smaller body mass and a lighter implement (J.G. Hay, 1993). Less effort is needed by women to counter the forces acting upon them than men due to the lighter ball, lighter body weight and the higher center of mass than men (J.G. Hay, 1993; Knudson, 2003). Men sit lower for increased stability to counter the greater forces placed upon the system (J.G. Hay, 1993).

The scientific literature has focused predominately on the characteristics of male throwers (Dapena, 1984, 1986; Dapena & Feltner, 1989; Dapena, Gutierrez-Davila, Soto, & Rojas, 2003; Dapena & McDonald, 1989; Dapena & Teves, 1982; Depena, 1985). Literature on female throwers has been limited to anthropometric data, performance information, and case studies (Barclay, 2000; Baronietz et al., 1997). No literature compares the differences between the throwing technique of male and female hammer throwers. The purpose of the research was to probe for possible technique differences between sexes in hammer throwing.

METHODS: Subjects for this study were the top finishers in the Men's and Women's Hammer Throw at the 2003 USA Track and Field National Championships (USATF) in Palo Alto, California (6 males and 7 females) and the top finishers in the Men's and Women's

Hammer Throw at the 2003 IAAF World Athletic Final, Szombathely, Hungary (8 males and 8 females). The University IRB board waived the need for informed consent since video taken at these meets is considered public domain.

Three digital video cameras (Canon model ZR40, Canon, USA) captured all footage of the event. The cameras filmed independently from one another. A 24-point model of the thrower represented the hammer-thrower system. The best throw of each of the 29 athletes was captured and imported into the Peak Motus system. Digitization began when the athlete was centered on both feet at the beginning of the second wind.

Conventional descriptive statistical methods calculated means and standard deviations. Analysis of variance determined differences in technique between sexes. Two linear regression analyses investigated differences in what determines performance between sexes. Statistical significance level was set at $p = 0.05$ level.

RESULTS: Men were heavier and taller than women. The angle of separation between the shoulders and hips was greater for men at the beginning of double support of turn two. Release velocities were greater for men. The location of the hammer head in the y direction at low point in turns two and three was greater for women. The time duration for turn one and the time within phase for double support of turn one were greater for men. The turn ratio in turn two was greater for women. Turn ratio is a comparison of single stance to double stance duration. The amount of centripetal force that developed in all phases of the turn except single support of turn two was significant. Finally, the amount the thrower's COM traveled in the x-y direction was greater among men.

DISCUSSION: The results of our analysis resulted in many significant variables. The variables of interest are: release velocity, release height, time, center of mass movement, shoulder to hip angle, and shoulder to hammer angle.

Extra body mass and increased athlete height in males is an advantage to throwing distance. These two variables impact release velocity and height (J.G. Hay, 1993) Release velocity can be greater with increased mass due to the increased ability to counter the centrifugal forces of the hammer with a backwards lean of the body. Subjects achieved an average release velocity of 29.2 m/s for males and 27.5 m/s for females. This seems reasonable with a past comparison between sexes previously reported as 26.2 m/s and 24.5 m/s for males and females, respectively (Hunter & Killgore, 2003). The differences between sexes are likely due to: 1) The extra body mass of males allows them to counter more effectively in order to generate greater angular momentum while maintaining balance as the throw progresses toward release, 2) the greater strength and power of males. Based upon previous work (Hunter & Killgore, 2003) and our results, males are able to generate a velocity of release greater than females even though they throw an implement of greater mass (7.26 kg for males and 4.00 kg for females).

Increased athlete height allows a greater release height which slightly increases flight time for men (J.G. Hay, 1993). Males were taller than the females and had a greater release height (1.41 m compared with 1.14 m) in our study. The greater release height is determined largely by anthropometrics (J.G. Hay, 1993). The result of this increased release height is a slightly longer throw assuming all other factors are maintained.

The distance the center of mass of the thrower traveled across the ring was different between sexes as shown by our results ($p<0.01$). Male subjects traveled an average of 1.56 meters in comparison to the average 1.37 meters female subjects moved. The ability to increase movement across the ring among male throwers is difficult since throwers already release at the front of the ring (Dapena, 1984). However, females have room for increasing displacement through the ring. This would be beneficial as increasing the distance the center of mass travels across the ring has a meaningful effect upon the measured distance of the throw (Dapena, 1986).

Time variable results provide an interesting picture regarding overcoming of inertia and buildup of centripetal force. Male shot putters generate a throw in less time, 0.4 seconds compared to 0.45 seconds for females despite throwing a heavier implement (Alexander et al., 1996). However in hammer throw, velocity build up is more gradual (Black, 1980; Bondarchuk, 1982; Dapena, 1984; Woicik, 1980). The average overall time of throw from the end of the winds until release was shorter for women (2.07 s) than men (2.22 s). Time for turn 1, male subjects took an average of 0.72 s compared to an average 0.64 s for female athletes, and within that turn, the duration of double support accounted for a time difference of 0.08 s between sexes. The greater mass of male hammer subjects and their implement account for the difference in total throw, turn 1, and double support time since a greater amount of inertia is overcome to initiate the throw. The results suggest the extra 0.08 s in double support of turn one enables male throwers to impart a longer torque period thereby increasing the large amount of angular momentum required for throwing the greater mass implement. Male subject turn ratio of single to double support duration for turns one and two was smaller than the women's. The turn ratio relationship results further supports the idea of longer torque application on the hammer during the double support phase for males during the first two turns.

The general movement and technique for male and female throwers is similar. However, there are certain characteristics that vary to some degree between sexes. Most of these differences are likely due to the height and body mass of the throwers and the heavier implement required for men. Coaches and athletes should be aware of these differences to help athletes progress towards optimal technique between sexes.

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