APPROACH RUN VELOCITIES OF FEMALE POLE VAULTERS

Peter M. McGinnis, Physical Education Department,
SUNY College at Cortland, Cortland, New York

INTRODUCTION

Running speed is an important determinant of success in many sports including pole vaulting. The approach run velocity of a pole vaulter is responsible for most of the vaulter's kinetic energy at the instant of take off. In a successful vault, this kinetic energy is transformed to potential energy which contributes to the maximum height achieved by the vaulter. For male pole vaulters, a strong relationship has been established between crossbar height cleared and approach run velocity (McGinnis, 1995). The purpose of this study was to determine if a similar relationship exists for women pole vaulters.

METHODS

A shuttered 60 Hz videocamera recorded vaults at four different women's pole vault competitions between 1995 and 1997. A 200 Hz videocamera was used instead of a 60 Hz camera at one competition. At each competition, the camera was positioned 20-60 m to the side of the runway and 5-20 m above the height of the runway. The camera's optical axis was perpendicular to the runway at a point 3-15 m from the back of the box. The shutter speed of the camera varied from competition to competition but was never slower than 0.004 s. The focal length of the camera's zoom lens was adjusted to maximize the image of the vaulter. This generally produced a field of view 3-6 m wide. The camera was panned to follow the approach run and vault by each vaulter. Prior to each competition, visible marks were placed on either side of the pole vault runway at four and nine meters from the back of the vault box.

The videorecords of the vaults were played back field by field on a videocassette player. The time it took a vaulter to move through the five meter interval was determined by counting video fields from the instant the vaulter first crossed the nine meter mark until she crossed the four meter mark. This count was then divided by 60 Hz or 200 Hz as time. For the 60 Hz videorecords, if the vaulter crossed the mark between video fields, then the count was increased or decreased by $^1/_2$ a field. The precision of the timing was thus 0.0083 s for the 60 Hz videorecords and 0.005 s for the

200 Hz videorecords. Average horizontal velocity was then computed by dividing the five meter displacement by the computed time. The accuracy of this velocity measurement technique was investigated by McGinnis (1991) who reported relative standard errors of less than 5%.

The single highest successful vault for each subject was chosen for analysis. A correlation and regression analysis was then completed using bar height as the dependent variable and approach run velocity as the independent variable.

RESULTS

Forty-one vaulters completed more than four hundred vaults in the four competitions. Four of the vaulters did not successfully clear a height in any of the competitions. Only the highest successful vault by each of the remaining 37 vaulters was included in the analysis. The 37 vaults analyzed had a mean height of 3.48 m (s.d.= 0.33 m). The lowest height was 3.01 m and the highest was 4.30 m. These vaults represent a wide range of abilities. A vault of 3.01 m may win local or regional competitions while a vault of 4.30 m may win national or international competitions. For comparison, as of May 12, 1997, the world record in the women's pole vault was 4.55 m and the American record was 4.45 m.

The vaults had a mean approach run velocity of 7.42 m/s (s.d.= 0.46 m/s). The slowest velocity was 6.58 m/s and the fastest was 8.22 m/s. The correlation coefficient between crossbar height and approach run velocity was 0.82 ($p < 0.0001$). The variance in crossbar height accounted for by the approach run velocity was 66.1%.

The linear regression equation which predicted crossbar height (h) from approach run velocity (v) was:

$$h = -0.91 + (0.59)\, v$$

and is shown in Figure 1. The standard error of the estimate for this regression equation was 0.195 m.

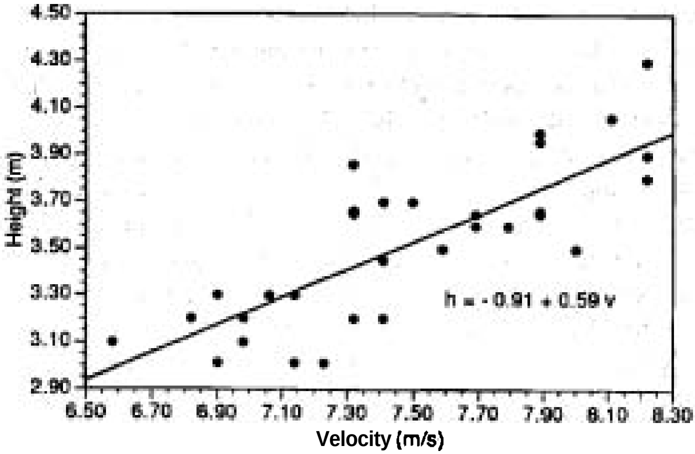

Figure 1. Regression line and scattergram of approach run velocity versus crossbar height for highest vault by each of 37 women pole vaulters.

DISCUSSION

The velocity of the approach run is significantly related to the crossbar height that a pole vaulter can clear. This relationship holds for both male and female pole vaulters as illustrated in Figure 2. The data for the male pole vaulters in Figure 2 represent the highest vaults recorded by 65 elite male pole vaulters and analyzed by McGinnis (1995). He reported a correlation coefficient of 0.73 ($p<0.0001$) between crossbar height and approach run velocity for these elite male vaulters. The linear regression equation which predicted crossbar height (h) from approach run velocity (v) for elite male vaulters was:

$$h = 1.22 + (0.46)\ v$$

A comparison of the two correlation coefficient indicates that the relationship between crossbar height and approach run velocity is slightly stronger for women than for men.

An examination of Figure 2 and the corresponding regression equations for the male and female pole vaulters is also revealing. Velocity data for the men and the women almost overlap at 8.30 m/s. With this approach run velocity, the regression equations predict that a man should vault 5.03 m and a woman should vault 3.99 m. The regression equations predict that men vault more than a meter higher than women with the same approach run velocities.

What are the reasons for the stronger relationship between height and approach run velocity for women, and the higher heights achieved by men with the same approach run velocity? The maximum height achieved by a pole vaulter is determined by four factors: (1) the vaulter' s energy at takeoff; (2) the work done by the vaulter from takeoff to pole release; (3) the energy lost from takeoff to pole release; and (4) the excess kinetic energy possessed by the vaulter at maximum height. The vaulter's approach run velocity largely determines the first factor. The other three factors are largely determined by the vaulter's technique. This is a relatively new event for women. Their techniques on the pole an not as well developed, so the heights they clear are primarily determined by their energy at takeoff which is largely determined by their approach run velocity. Men on the other hand, have more well developed techniques on the pole. The heights they clear are determined by their techniques as well as their approach run velocities.

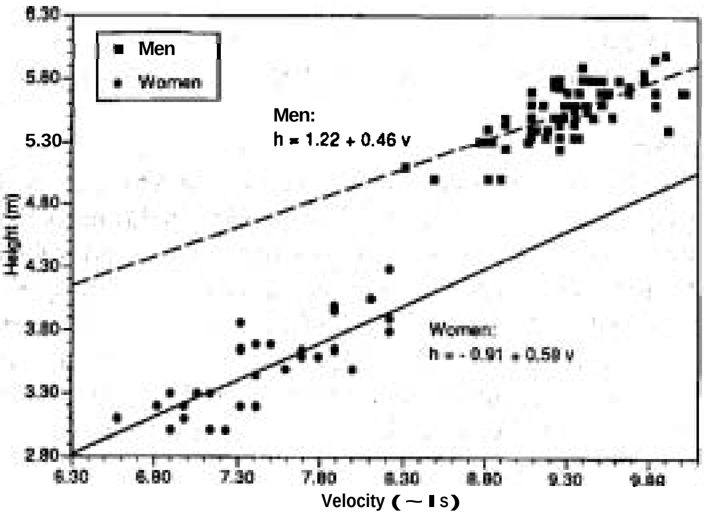

Figure 2. Regression lines and scattergrams of approach run velocity versus crossbar height for highest vault by each of 37 female and 65 male pole vaulters.

Even with more experience and better technique on the pole, the regression line for women will still fall below that of men. Although the difference may not be as large as a meter (as it is now), the deficit will still be significant. The reason for this is because men are more powerful than women. One of the factors which determines the height achieved by a pole vaulter is the amount of work done by the vaulter on the pole. Most of this work is done by the trunk and shoulder muscles. The more powerful these muscles are, the more work the vaulter will be able to do, and the higher the vault.

CONCLUSIONS

A significant positive correlation exists between approach run velocity and height cleared by women pole vaulters. This relationship is stronger for women vaulters than for men. Success in women's pole vaulting is thus more dependent upon approach run velocity than it is in men's pole vaulting.

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REFERENCES

McGinnis, P. M. (1991). The accuracy of devices and techniques for measuring the speed of athletes. In C. Tant, P. Peterson, & S. York (Eds.), Biomechanics in Sports IX: Proceedings of the 9th International Symposium on Biomechanics in Sport, (pp. 177181). Ames, IA: Iowa State University.

McGinnis, P. (1995). Predicting performance potential in the pole vault from approach run velocity. In Third IOC World Congress on Sport Sciences Congress Proceedings (pp. 182-183). Atlanta: ACOG.