PREDICTING POTENTIAL JUMP HEIGHT IN THE POLE VAULT FROM FOUR VARIABLES

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This study evaluated how well pole vault performance variables predict vault height. Personal best (PR), flying 30m sprint (F30), ten step long jump (10LJ), and straight arm 45° strength test (SA45) were collected from 165 pole vaulters (13-19 years old) during three vaulting camps. Stepwise regressions to predict PR were compared by gender and performance related groups. The males' prediction equation included the F30 and 10LJ and for females included only the F30. Due to gender PR differences, the subjects were re-grouped according to vault height. The higher performers' equation included the F30 and 10LJ and the lower performers' equation used only the F30. Equations based on current capabilities seem to be better than those based on gender.

KEY WORDS: pole vault, testing, prediction equations, adolescent.

INTRODUCTION: Many believe approach speed to be the greatest predictor of success in the pole vault (McGinnis, 1995 & 1997; Adamczewski & Perlt, 1997; Hay, 1993; Angulo- Kinzler, 1994). Most research has correlated approach velocities to vault height in a wide range of pole vaulters. There have been several equations developed in the research for predicting pole vault potential. McGinnis developed one for men in 1995 and another for women in 1997 based on approach velocity. A study by Adamczewski & Perlt (1997) evaluated adolescents between 16 and 17 years of age and reported males and females equations separately. Both studies used running speed as the single predictor of vault height, but they did not examine the influence of other variables such as specific strength in the upper body or takeoff ability. These variables may also have an influence on overall success in the pole vault. Angulo-Kinzler (1994) suggested that in addition to the speed, the athlete must be in a position to leave the ground during the takeoff phase to maximize energy transfer from horizontal to vertical. The amount of energy present when the athlete leaves the ground is largely dependant on the amount of speed created on the runway (Hay, 1993). Overall, the amount of energy during each vault that is created or lost can result in a higher or lower vault.
Recently there has been an increase in the number of research studies attempting to find tests that will help coaches to predict placement in certain events in track and field. Seese (2003) suggested that lifting strength in the weight room (relative to body weight) when added to time for a 30-meter sprint could create a coefficient that may be used as a predictor of pole vault potential. Sullivan, Knowlton, Hetzler & Woelke (1994) examined anthropometric variables along with a few other technique factors for predicting pole vault performance of adolescents. They found that grip height had the highest correlation to vault height and other variables strongly correlated to grip height; the other variables included the 100 foot sprint with a pole and standing long jump. Some texts, Henson & Turner (2000) for example, have encouraged coaches to train their pole vaulters in more areas besides speed, such as jumping ability, gymnastics ability and strength. Although these studies reported a greater variety of variables as predictors of success, they neglected several event specific variables like running long jump, inverting drills, or speed tests with a running start as opposed to starting them from a dead start. The goal of this study was to evaluate the accuracy of speed, strength and technique variables to predict performance in 13-19 year old pole vaulters.

METHOD: The participants (N = 165) were high school aged, ranging from 13 to 19 years old, and attending a pole vault camp in the Midwestern United States. They completed each testing phase during the camp and their performances were recorded in a data log sheet. All participants were required to perform the tests as long as they were physically healthy. Those that did not participate in the tests were not included in the data analysis. Ten participants were lost due to inability to complete all the tests.

Data Collection: Each participant was asked to perform the following tests: a flying 30-meter dash (F30), a ten stride long jump (10LJ), and a straight arm 45° (SA45). Descriptive information for the group are reported in Tables 1 and 2. The participants were asked to provide their personal best vault (PR) during orientation at the beginning of camp. Flying 30s were measured using an infrared timing system with two gates. The participants were taken through a warm up procedure and then the faster of the two attempts was recorded in seconds. The participants completed two trials on the 10LJ. This test required them to take an approach of 10 foot touchdowns and long jump into a sandpit off the foot that they takeoff from in the pole vault. The long jump distance was used as a measure of technique and effectiveness of jumping off the ground. The SA45 drill was completed during an inverting drill session. Participants were asked to lay on a box and invert to a vertical position. They were required to hold their body in a straight line at 45 degrees from the horizontal with their arms fully extended above their head gripping a small section of pole. Time, in seconds, was measured while stable at 45 degrees and not pulling with the arms for an isometric measure of strength used to invert on a pole.

Statistical Analysis: A t-test was used to compare all variables by gender. Stepwise linear regression was performed with PR as the dependant variable and F30, 10LJ, and SA45 as the independent variables. Regression equations were created for groups by gender. Because of gender differences, a second set of regression equations were created for groups based on PR. Based on a vault height histogram, the performers seemed to have a bimodal performance distribution. The value that seemed to separate the two groups was about 3.20m, so all subjects at or below 3.20m were assigned the low group and those above this value were assigned to the high group. Significance for all tests was determined at the alpha level of 0.01.

RESULTS: Regression equations for each gender and group are presented in Table 3. The male prediction equation yielded the F30 and 10LJ as significant predictors of vault height. The female prediction equation had only the F30 as a significant predictor of vault height. Additionally, when data for both genders were combined, the F30 and 10LJ were both entered as predictors to vault height. For each of the four variables used, males were significantly higher than females. Because the differences may have been performance related and not exclusively gender related, another stepwise linear regression was performed to examine the differences between groups based on vault height performance and not according to gender. The higher jumping group yielded the F30 and 10LJ both as predictors. The lower group produced just the F30 as a significant contributor.

Table 1. *Descriptive statistics of subjects. (N=155)*

	Age (yrs)	Ht (m)	Wt (kg)
Male	16.5±1.2	1.7±0.1	66.4±7.7
Female	16.4±1.2	1.6±0.1	57.2±6.8
Overall	16.4±1.2	1.7±0.1	62.6±8.6

Table 2. *Descriptive information for predictor variables. (N=155)*

	PR(m) *	F30(s) *	10LJ(m) *	SA45(s) *
Male	3.76±0.60	3.54±0.26	4.83±0.50	13.8±13.9
Female	2.79±0.47	4.11±0.31	3.73±0.50	5.1±8.2
Overall	3.32±0.73	3.80±0.40	4.32±0.74	9.8±12.4

Note. Significant differences between gender: *$p < .01$

Table 3. *Equations for pole vaulting height based on testing factors.*

Groups	Equations*	*n*	R^2
Males:	PR= F30(-0.879)+ 10LJ(0.419)+ 4.849	85	0.488
Females:	PR= F30(-1.126)+ 7.386	70	0.494
Combined:	PR= F30(-0.804)+ 10LJ(0.432)+ 4.489	155	0.733
Combined Low:	PR= F30(-0.745)+ 5.728	74	0.431
Combined High:	PR= F30(-0.647)+ 10LJ(0.297)+ 4.743	81	0.482

*all equations significant predictor of PR ($p < .01$)

DISCUSSION: Just as previous research found approach as a key component in pole vaulting, so did the results of the equations from current regression analysis. These results were also comparable with the expectations of Hans, Adamczewski, and Wolf (1994), who suggested as performance improves, takeoff ability and other factors begin to influence vault height in addition to running speed. Several equations that involved only the F30 yielded R2 values similar to those reported in McGinnis (1995, 1997) and Adamczewski and Perlt (1997) that used approach velocities as their only predictor variables. The combined equation for all subjects in the present data resulted in the F30 and 10LJ accounting for73.3% of the variance in vault height. When comparing the analyses of the two different groupings, the combined low equation of both males and females resulted in the same variable entered (F30) and a similar accounted variance in vault height as the equation using only the females' data. Based on the performance-based group equations it seems that as vaulting heights increase the technique skills, such as the 10LJ, become meaningful in predicting the ability of the pole vaulter to achieve higher jumps. This agrees with the implications of McGinnis (1997) and Hay (1993). A future study may incorporate elite level performers on additional technique or specific strength oriented tests, such as the SA45 or Bubka drill, to determine if tests of this nature would have a significant contribution to vaulting higher just as the speed and jumping ability do at this age and vaulting level. Perhaps future research may continue to develop specific tests for the pole vault that can be easily utilized by all coaches. Retaining the advantage to the present method of easily obtainable variables would be an advantage to many coaches.

CONCLUSION: These results may help coaches to determine what to emphasize when training younger athletes. Yet, as they progress and eventually reach higher heights, around 3.20 meters, it may be expected that technique and power will begin to factor into their potential to succeed. It would be misleading to use an equation for males who are performing at lower heights because their performance would not justify such a use. Perhaps the performance of an athlete may be more important in deciding which equation to use as a predictor and not gender. As future studies examine higher level performers and the relationships between certain tests and their vault height, there is a possibility that strength may factor into the equation significantly. The knowledge gained from this can be applied to training as well as testing young athletes to become successful pole vaulters. These results include a practical analysis that would help to assess the abilities of athletes to determine whether they have the potential to do well physically in the pole vault event.

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