Evaluation of the Efficient Motion in the Running Long Jump

S. Fukashiro

Laboratory for Physical Activity Sciences,
National Institute of Fitness & Sports In Kanoya, Japan

INTRODUCTION

The running long jump consists of four consecutive parts: the run-up, the take-off, the flight and the landing. The role of the run-up is to get the jumper to the optimum position for take-off with as much speed as he can control during that part of the jump (Hay, 1973). In other words, it is important for the long jump to utilize effectively the kinetic energy saved during the run-up to the take-off. The transition from the run-up to the take-off (the last 3 to 4 strides before take-off) is regarded as one of the most important parts in the technique of long jumping. It could be said that the performance is composed of the run-up velocity and the technique to utilize the velocity. So, in order to examine the efficient motion pattern, the model of causal-relationship (see Figure 1) is presented based on this consideration. Using this model, the efficient pattern can be evaluated without any effect of the physical resources.

Several researchers have studied the long jump from the kinetical and the kinematical viewpoints such as the ground reaction force (Bosco et al. 1976, Ramey 1970), the joint angle of supporting leg during take-off (Klissouras & Karpovich 1968), and the body orientation in the flight phase (Herzog 1986). However, the degree of contribution of the technique itself to the performance has not been investigated in these previous studies.

The purposes of this study are to present the methodology using statistics in the analysis of the long jump, and to examine the efficient motion for getting high performance.

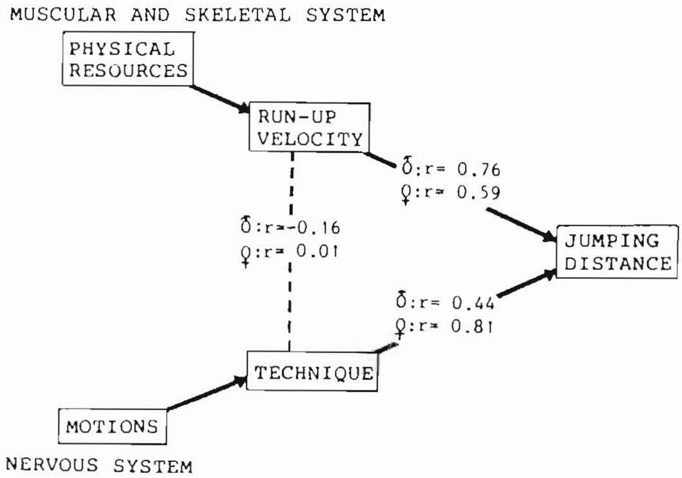

Fig. 1. Representative model of causal-relationship in the running long jump.

METHODS

Healthy 46 persons (22 males, 24 females) aged 14-17 yrs performed the running long jump and the maximal sprint running (50m). Their motions, which are the jumping form from the last of run-up to the landing and the springing form at a constant speed phase, were filmed (100 frames/s) by a 16 mm high speed cinecamera (Photo-Sonics) from a side view. The run-up velocity (the horizontal velocity of the hip before touch-down of take-off) and the kinematical variables shown in Figure 2 were obtained by using the motion analyzer (NAC). In the present study, six variables were selected as motion pattern during take-off and landing which must affect to performance. On the other hand, the height, the body weight and the maximal isometric strength of seated leg extension and back extension were measured as factors of the physical resources.

There are significant correlations between the run-up velocity and the jumping distance in male and female, respectively (Figure 3). Based on the hypothesis that the performance consists of the run-up velocity and the technique, the technique can be estimated from vertical distance between each data of the subject and the regression lines of male or female.

Multiple regression analysis is used to examine the inter-relation of each variable in the model of Figure 1. The jumping distance as a dependent variable is analysed first by using the run-up velocity and the technique as independent ones. In the next step, the dependent variables (i.e. the run-up velocity or the technique) are conceptualized as global variations which include the selected variables, i.e. the physical resources or the motions, respectively. In detail, the standardized Beta (mean: 0, variance: 1), multiple correlation coefficients (R) and R square were calculated.

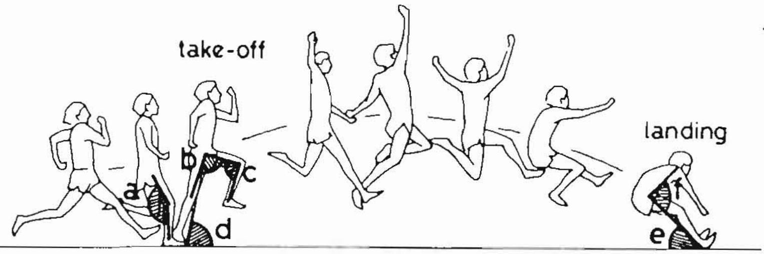

Fig. 2. The measured variables (a-f) of the running long jump.
a) maximal knee flexion of supporting leg, b) angle between each thigh, c) knee angle of swinging leg, d) angle of supporting leg at take off, e) angle of leg at landing, f) angle between trunk and leg.

RESULTS AND DISCUSSION

(1) The model of causal-relation in the long jump.

Dyson (1968) stated that the top jumper has attained, perhaps, no more than 95% of his top sprinting speed in the run-up. Hay (1973) also described that the jumper must control the take-off motion with as much speed as he can. However, some students run at their maximal speed as shown in Figure 3. These data in this figure are plotted at near the identical line (r = 0.78, n = 46). The run-up velocity of the student differs slightly from the top athlete.

The run-up velocity was defined as the physical resources in the hypothesis, inclluding that the jumper who has high sprint ability can generate the large external force during take-off. However, the jumper without technique can not get high performance even if he can run at quite fast speed. There are significant positive correlations between the jumping distance and the run-up velocity or the technique. The faster the run-up is and the ligher the technique is, the greater the performance is.

The values of Beta in the technique and the run-up velocity are as follows: 0.49 and 0.79 in male, and 0.81 and 0.58 in female, respectively. It might be said that the performance of male is mainly contributed to by the run-up velocity and that of female is contributed to by the technique. Therefore, the hypothesis is accepted in the analysis of the long jump from the statistical viewpoint.

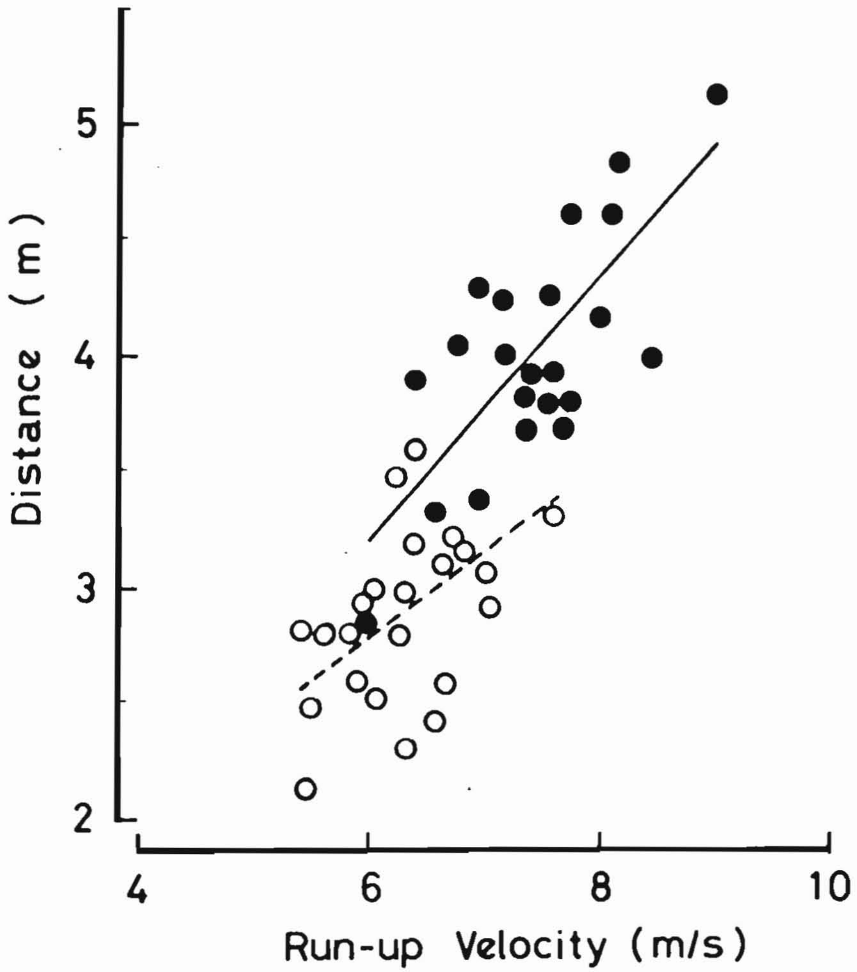

Fig. 3. Relationship between run-up velocity and distance.
male, r=0.76, p 0.001, : y=0.569×−0.24
female, r=0.59, p 0.01, : y=0.361×+0.59

(2) Relation between run-up velocity and physical resources.

One of the advantages of the multiple regression analysis is to examine effects of many variables. However, since one of the purposes of this study is to indicate the methodology in the analysis of the long jump by using statistics, the selected variables were used as physical resources and motions.

Table 2 shows the result of multiple regression analysis on run-up velocity and physical resources. In male, the muscle strength of leg extension is the most contributing factor to the run-up velocity. Fifty-five percent of the variance in the run-up velocity is accounted for only by the leg extension strength, although 67% is accounted for by all 4 independent variables. It can be said that the run-up velocity in male is mainly determined by the muscle strength of the leg.

However, in female, only 14% is accounted for by all 4 variables and there are no significant correlations between the run-up velocity and the independent variables. Therefore, in the case of female, another factors must determine the run-up velocity.

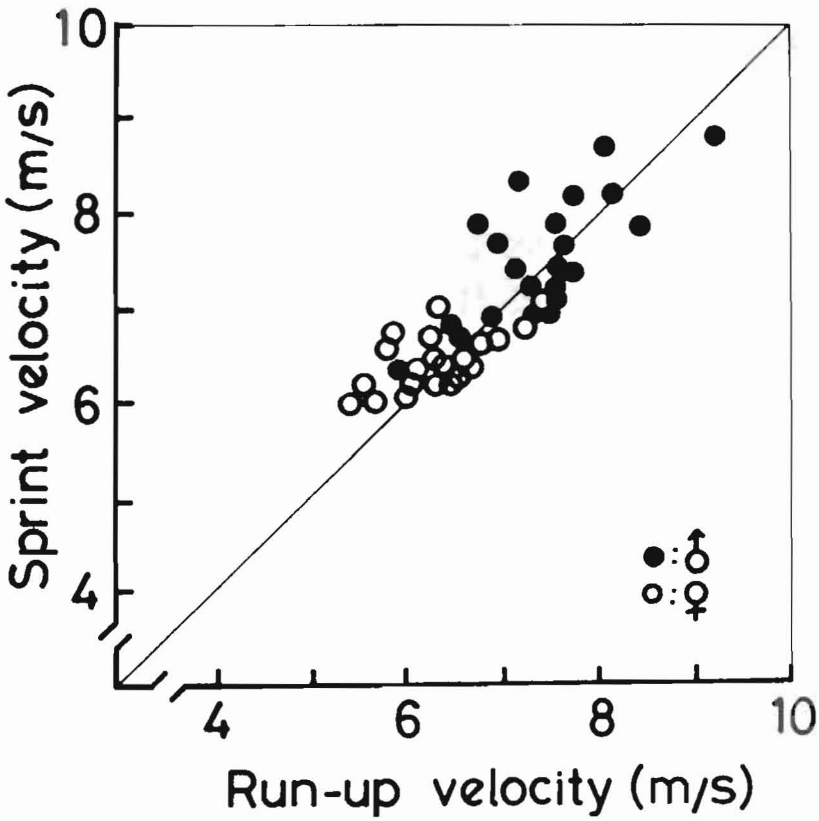

Fig. 4. Relationship between run-up velocity and sprint velocity. male: r=0.638, p 0.01, female: r=0.529, p 0.01

TABLE 1

Means and standard deviations in the physical characteristics, the jumping distance and the angles of motions.

	MALE (n=22)	FEMALE (n=24)
Height (cm)	165.3 (5.3)	155.2 (4.3)
Weight (kg)	54.4 (7.2)	46.6 (3.9)
Strength: leg (kg)	54.2 (13.7)	37.7 (7.9)
: back (kg)	102.9 (20.1)	73.7 (11.2)
Long jump (m)	4.02 (0.53)	2.90 (0.35)
Item «a» (deg)	164.0 (10.2)	153.9 (13.1)
«b» (deg)	96.5 (10.8)	87.5 (8.0)
«c» (deg)	62.3 (11.0)	71.0 (12.9)
«d» (deg)	66.1 (3.9)	67.4 (4.0)
«e» (deg)	43.7 (6.0)	48.5 (5.8)
«f» (deg)	102.6 (18.0)	113.1 (19.1)

≠ These data present that the subjects in this study are the average students in that age.

TABLE 2

Relationship between run-up velocity and physical resources.

	MALE		FEMALE	
	r	Beta	r	Beta
Height	0.320	0.313	0.162	-0.055
Weight	-0.427*	-0.257	0.244	0.418
Strength: leg	0.611**	0.858	-0.055	-0.381
: back	0.347	-0.191	0.121	0.189
	R =0.817 R^2=0.668		R =0.370 R^2=0.139	

*: Significant at 0.05

**: Significant at 0.01

r: simple correlation coefficient.

(3) Relation between technique and each motion.

Table 3 shows relation between the technique and each motion. In male, the most contributing motion to the technique is the angle "d" of supporting leg and the next one is the angle "c" of knee joint of swinging leg at take-off. Fifty-eight percent of the variance in the technique is accounted for by only these 2 parameters. From these results, it can be said that the important motions for getting great jumping distance is shown; to resist the forward rotation of the body by the hinged moment (or to keep the trunk and supporting leg errect), and to swing the free leg well flexed at the knee by decreasing the inertia moment at take-off, as indicated by Dyson (1968). Furthermore, the position of leg "e" at landing and the angle "b" between each thigh also contribute to technique, although role of these motions are relatively small compared to the motion "d and c". Pull-up of the thigh at take-off and the leg at landing must be also desirable form.

On the other hand, in female, the contribution of the variables "e and b" are relatively large, i.e. 49% of the variance in the technique is accounted for by these 2 variables. The variables of "c and d" are also important. The most important variable for female is pull-up of the leg at landing. This result agrees well to previous reports (Dyson 1968,

TABLE 3

Relationship between technique and motions.

	MALE		FEMALE	
	r	Beta	r	Beta
Item «a»	0.257	-0.069	0.157	0.117
«b»	0.070	0.238	0.368	0.446
«c»	-0.288	-0.393	-0.231	-0.335
«d»	0.560**	0.828	0.288	0.208
«e»	-0.195	-0.343	-0.573**	-0.576
«f»	-0.145	-0.019	-0.043	0.091
	R =0.806 R^2=0.650		R =0.803 R^2=0.645	

r: simple correlation coefficient.
**: significant at 0.01

Fukashiro & Miyashita 1983), which indicated the importance of landing motion.

The important variables (b, c, d and e) and not important variables (a and f) to get great jumping distance are the same in both male and female. However, the sequence of the contributing variables differs in male and female as mentioned above.

CONCLUDING REMARKS

The result of statistical analysis agrees well to the explanation by biomechanical principle. If this method is adopted to different groups such as children, students and top and/or second-class athletes by using many variables of the motions, the efficient motion in each group will be well suggested. In the future, the statistical method will be more and more important in the mechanical analysis in the field of biomechanics.

REFERENCES

Bosco, C. et al. Kinetics and kinematics of the take-off in the long jump. In Komi, P.V. (ed.), Biomechanics V-B, University Park Press, Baltimore, p. 174-180. (1976).

Dyson, G. The mechanics of athletics. University of London Press Ltd., London, p. 151-160. (1968).

Fukashiro, S. and M. Miyashita A biomechanical study of the landing in triple jump. In Winter, D.V., et al. (eds.), Biomechanics IX-B, Human Kinetics Publishers, Champaign, p. 454-457. (1985).

Hay, J.G. Biomechanics of sports technique. Englewood Cliffs, NJ: Prentice-Hall, p. 420-425. (1978).

Herzog, W. Maintenance of body orientation in the flight phase of long jumping. Med.Sci. Sports Exerc. 18(2): 231-241. (1986).

Klissouras, V., and P.V. Karpovich. Electro-goniometric study of jumping events. Res. Quart. 38(1): 41-48. (1968).

Ramey, M.R. Force relationship of the running long jump. Med.Sci.Sports 2: 146-151. (1970).