Biomechanics of the Long Jump

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Generally speaking, the performance of long jump determined by horizontal velocity and vertical velocity in the direction of center gravity at take–off.

Therefore, the jumper tries to develop as much vertical as possible without an appreciable loss of horizontal velocity developed during the approach running.

In order to analyze the movement of the long jump of the running we have been used force platform and 16mm cinecamera a technique (C.Bosco.1975 M.R.Ramey 1973 1975.) report that distance of long jump increased with vertical velocity at take–off. Matsui et al. (1973) indicated that a significant higher correlation was observed between approach running speed and jumping performance.

The study of take–off velocity is, however, still not sufficient on long jump.

The purpose of the present study is to observe the effect take–off velocity on performance of long jump.

METHOD

The subjects were male long jumper (record 7.51 – 6.74 m, Table 1). The subjects were university students.

Each subject was requested to take a run of 5 , 10, 20 m and free distance from take–off point. All measurement were taken for three long jumps on each approach distance.

The running course was made from rubber mat in the outdoor track (Fig. 1).

The ground reaction force exerted by the foot at take–off was measured on a force platform (Fig 1). All measurment were made on a force platform which recorded the force–time curves in X and Y directions. The force from the force plat form was recorded in datarecoder for subsequent analysis.

To observe the motion of body 16mm movie camera

Table I. Characteristics of the subjects.

Subject	Age (yrs)	Body Height (cm)	Body Weight (kg)	Best Record Long jump (m)	Best Record 100m (sec)	Approach Distance (m)
NKN	20	174.6	62.0	7.51	11.7	44.0
TUB	22	171.6	68.0	7.14	11.4	41.0
UKI	22	172.1	60.0	6.97	11.6	45.0
SAN	21	166.0	56.0	7.03	11.4	41.0
NKO	22	173.0	64.5	6.95	11.7	42.0
OUH	19	165.8	58.5	6.74	12.0	35.0
Mean	21	170.40	61.50	6.92	11.63	41.33
S.D.	±1.15	±3.39	±3.94	±0.409	±0.21	±3.20

(D.B.Milliken–55) was operated 100f.p.s. The 16mm movie camera was placed at a distnce of 30 m at right angle of the force platform.

The force–time relationship obtained from the records of the force platform was used to calculate the velocity of center of gravity by making use of impulse momentum relationship. However, the velocity of center of gravity was obtained from the of analysis of the film.

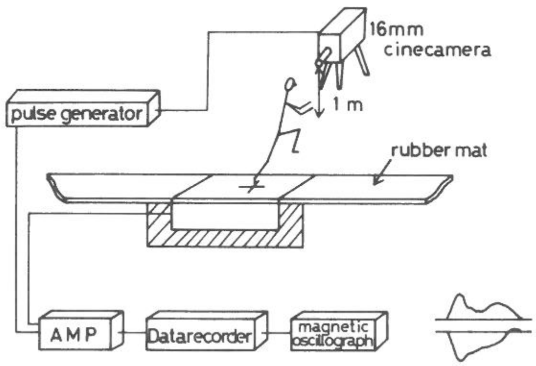

Fig. 1. Schematic illustration of experimental apparatus.

Another data was used in the ballistics equations to calculated the distance that the center of gravity of the jumpers moved during the jumping. The take-off velocity can be substituted into the ballistics equations of physics to get the distance in which the center of

$$X = \frac{Vh\left[Vv + \sqrt{(Vv)^2 + 2\,g\,y\,o}\right]}{g} \quad \cdots\cdots\cdots \ (1)$$

gravity moves. If air resistance is neglected, the horizontal distance is given by the ballistics equations (1).

X = the horizontal distance of center of gravity that the of gravity moves.

Vv = the horizontal component of the take-off velocity of jumper's center of gravity.

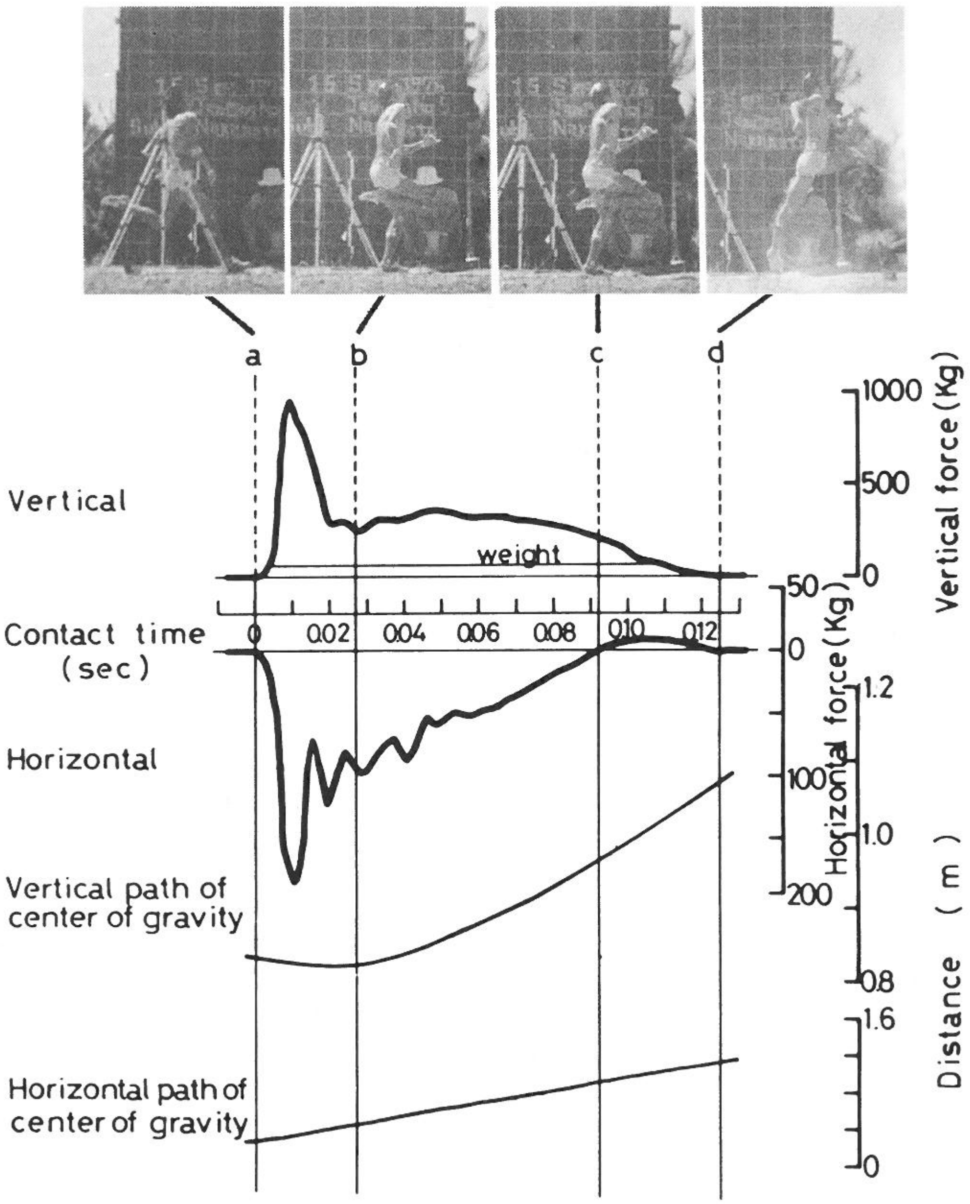

Fig. 2. Schematic representation of a typical take-off.

Vv=the horizontal component of the take-off velocity of the jumper's center of gravity.

yo=the initial height of jumper's center of gravity.

g =the acceleration due to gravity.

RESULTS AND DISCUSSION

The results obtained by a typical jump are illustrated in fig. 2 is a sequence of 16mm still during take-off. Whill, below of fig. 2 is the vertical force-time relationship, horizontal force-time relationship, a plot of the vertical position of the jumper's center of gravity (CG) and the horizontal position of CG with respect to time.

The characteristic point of changing of the CG pattern are:

a=first of initial contact point at force platform.

b=the lowest of CG on force platform.

c=force exerted by the foot transfers from going forward to going backward running in force of horizontal direction on force platform.

d=take-off point on force platform.

This force-time relationship in vertical phase can be separeated into two primary region of impacct (a−b) and thrust (b−d) .Smilarly, the force-time in horizontal phase can separeated into two regions.

The major force in vertical phase (b−d) is used to propel the body upward.

The major force in horizontal phase (a−c) is ued to decrease foward speed. Whill, the major force in horizontal phase (c−d) is used to increase forward speed. Therefore, the Vv of CG increases with the force-time in vertical impulse (b−d) at take-off.

Further, when horizontal impulse (a−b) increased during take-off, Vh of CG increased.

The significant correlation coefficient was found between Vv at take-off and change in Vv Vh during tale-off ($r=0.560$ $p<0.01$ Fig 3) .

However there significant between Vv/Vh distance of jump ($r=-0.779$ $p<0.001$ Fig 3) .

As shown in the fig. 4 the distance of actual jump decreased with an increase of Vv at take-off.The significant was found between distance of actual jump and Vv at take-off.

The fig. 5 showed relationship between Vv/Vh at take-off and distance of actual jump.

The distance of actual jump decreased with an increase of Vv/Vh at take-off.

There was a linear relationship between Vv/Vh and distance of actual jump ($r=-0.908$ $p<0.001$) .

These results showed that Vh was more important Vv at take-off in order to jump father. Thus, it indicated that change of Vh was less important than the increase of increase of Vv at take-off.

This study showest that Vv/Vh at take-off must be under approximately 30% for good performance.

C.Bosco et al. (1975) have reported that performed to develop the ability of his leg extensor muscle utilize the coupling of the eccentric-concentric contractions and at immediately following the impact.

Additionally, we have reported (1976) that the

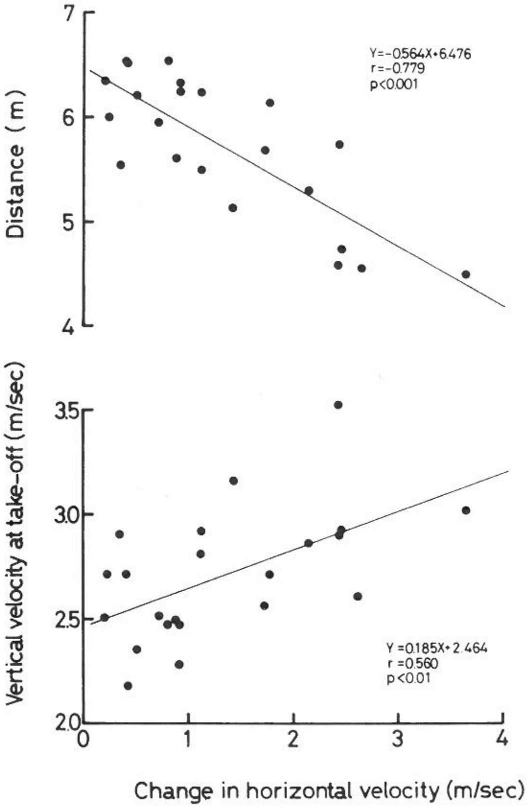

Fig. 3. Jumped distanec (upper) and vertical component of velocity (lower) at take-off in relation to change in horizontal component of velocity at take off.

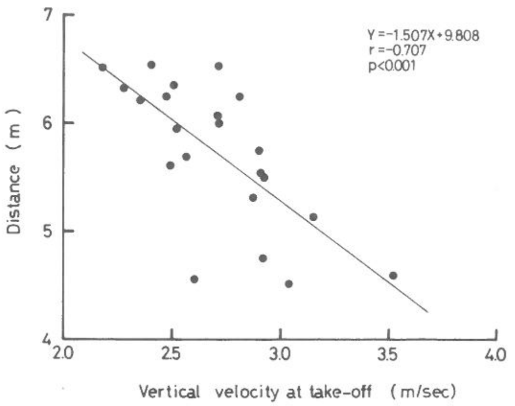

Fig. 4. Relationship between jumped distanec and vertical component of velocity at take–off.

distance of actual long jump increased with a decrease cntact time during take–off.

Therefore, it may indicated that jumper performed to raise body itself to utiliize the coupling of extensor muscles and kicked with the tops of the toes at take–off.

The fig. 6 showed the relationship between actual distance of actual jump and calculated distance from the ballistics equation.

The distance in both group increased with a increase of Vh at take–off. The signigicant high correlation coefficient was found between Vh at take–off and distance in both groups (the distance of actual jump r=0.973 $p<0.001$, calculated r=0.969 $p<0.001$).

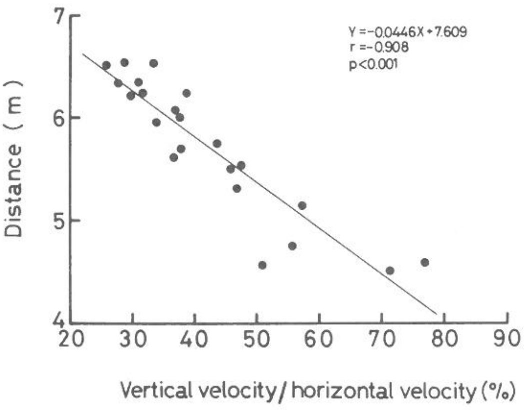

Fig. 5. Relationship between jumped distance and vertical component of velooity/horizontal component of velocity at take off.

However, distance of actual jump was longer than calculated distance in lower Vh at take–off.

As these results suggested that athletes performed to do the action of their leg extenser at landing in lower Vh on take–off. On the other hand, athletes can not perform landing in in high Vh on take–off.

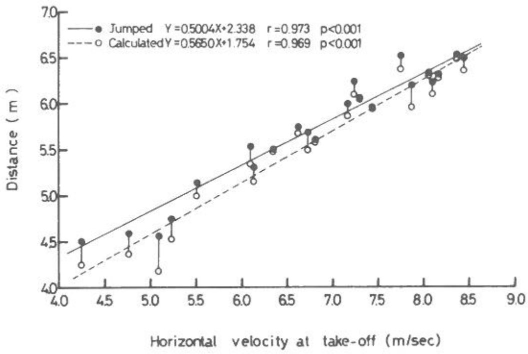

Fig. 6. Relationship between horizontal component of velocity at take–off and jumped distance.

Fig. 7 shows the relationship between Vh and Vv at take–off. The line curves in fig. 7 showed the calculated distance of CG by the use of ballistics equations. When the ballistics equation was used, air resistance was neglected and the high of CG was 1 .10m at take–off. The date of figure means distance of actual jump for each subjects and other mark (X and M) were the date by Mastui et al. (1973) and Ramey (1970). The negative relation was observed between Vh and Vv at take–off (r=-0.819 $p<0.001$). As shown in figure 7, the Vv at take–off decreased with an increase of actual distance of jump.

Further, the Vh at take–off increased with a decreased of actual distance of jump.

According to the present study, there are two types of jumper's who depend on either Vv or Vh at take–off. We indecate that good move of take–off is depends on his leg extensor muscle in each subject.

Finally, the knowledge of horizontal and vertical velocity relationship can be used for the study of the efficiency of take–off.

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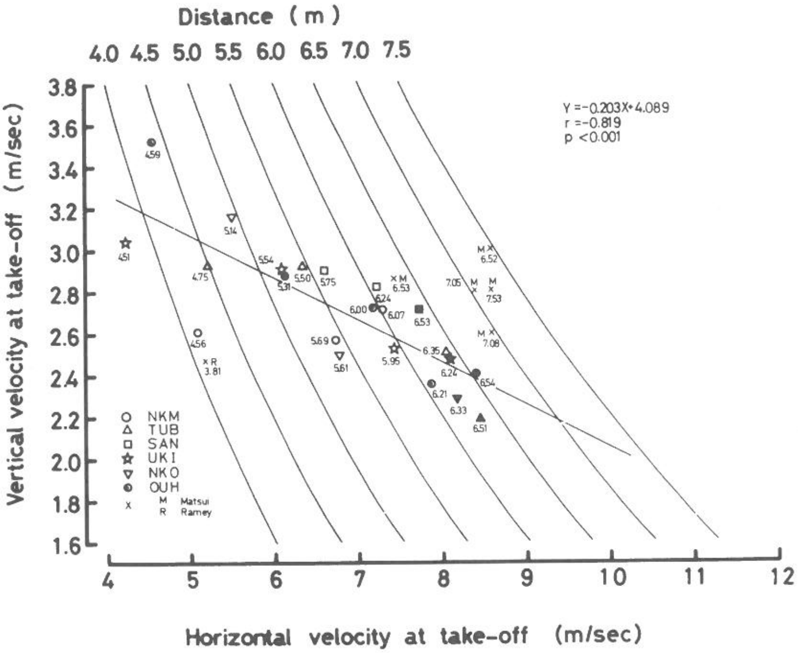

Fig. 7. Relationship between horizontal component of velocity and vertical component of velocity at take–off.

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