

THE EFFECT OF RUN-UP SPEED ON LONG JUMP PERFORMANCE

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The effect of run-up speed on long jump performance was systematically examined using a technique intervention study. The results from the study were in good agreement with theoretical models and confirmed the accepted wisdom that the faster your run-up, the farther you will jump. However, the strength of the relation between jump distance and run-up speed (8 cm per 0.1 m/s) was less than that suggested by a cross-sectional study (13 cm per 0.1 m/s). We propose that the trend line from the technique intervention study indicates the improvement to be expected from better running technique, whereas the trend line from the cross-sectional study indicates the improvement to be expected from increased muscular strength.

KEY WORDS: athletics, long jump, run-up, intervention study, cross-sectional study.

INTRODUCTION: Many studies of the biomechanics of long jumping have used a cross-sectional correlation study design. In such studies a representative trial by a number of performers is analysed and the technique variables that have a significant influence on the performance criterion are deduced. Studies by Hay *et al.* (1986), Hay (1993), and Lees *et al.* (1993; 1994) identified run-up speed as having the strongest correlation with jump distance. However, Bartlett (1999) warns that that a high correlation does not imply a cause and effect relation between the technique variable and performance, and that the results of a cross-sectional study cannot be generalised to a specific athlete. Technique intervention studies are another potentially fruitful avenue of investigation, but they have seen little application in understanding and improving sports performance. In this type of study an important technique variable is deliberately varied, preferably over a wide range of values, and the resulting changes in the performance of the athlete are noted (Greig and Yeadon, 2000). This is an effective method for revealing the causal relations between technique and performance, and it can provide significant insights into improving the performance of an athlete. The present study used a technique intervention strategy in which the run-up speed of a long jumper was systematically varied to produce changes in jump distance. The results of the study were compared to previous cross-sectional and theoretical studies, and the implications for the speed training and strength training of long jumpers was examined.

METHOD: A male long jumper with a personal best performance of 8.25 m was recruited for the study. The athlete jumped for maximum distance several times using his normal competition run-up speed, and then several more times using shorter and slower run-ups. The jump distances were measured with a fibreglass tape, and the jumps were recorded in the sagittal plane with a high-speed video camera operating at 100 Hz. An Ariel Performance Analysis System was then used to determine the horizontal speed of the athlete's centre of mass in the last stride before takeoff.

RESULTS: The relation between run-up speed and jump distance obtained using the technique intervention study (Figure 1) was clearly different from that for the cross-sectional study of Hay (1993). A difference is to be expected because of the different aims and designs of the two studies. The cross-sectional study considered many jumpers of different ability; from mediocre high school athletes (lower left) through to elite male athletes (upper right). These athletes were attempting to achieve their maximum possible distance. That is, the data points are maximum (or near-maximum) performances, where the athlete has used a self-selected jumping technique that was intended to be close to the optimum for the athlete's physical capabilities. (In long jumping, the optimum technique is usually to use the fastest possible run-up and to spring upwards as much as possible at takeoff.)

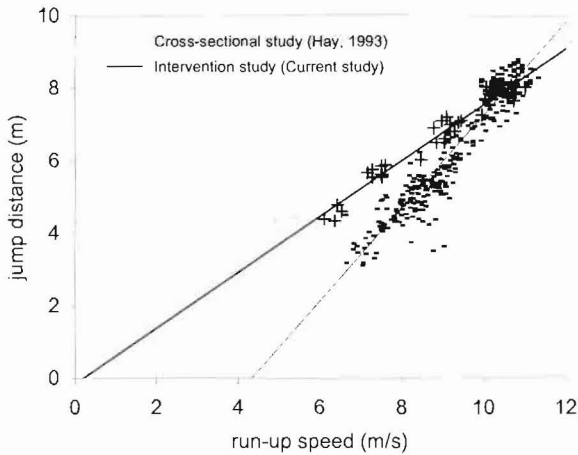


Figure 1. Comparison of results from a cross-sectional study and a technique intervention study. (Cross-sectional data courtesy of Jim Hay.)

In contrast, the intervention study reported here considered only a single athlete. Although the jumps by the athlete were always at maximum effort, the jumps with the slower run-ups were *not* employing the optimum technique that would result in the maximum possible jump distance. However, at any given run-up speed the technique used by the athlete was close to the optimum for that run-up speed. This is a reasonable assumption because the athlete was highly experienced and regularly performed jumps from a short run-up as part of his normal training program. The trend line for the intervention study intersects that for the cross-sectional study at a jump distance of about 8 m. This is expected because data points in this region correspond to conditions identical to those for the cross-sectional study; namely, jumping for maximum possible distance using a near-optimum technique.

Speed Training: The results from the technique intervention study confirm the role of speed work in the training program of the long jump athlete. The faster your run-up, the farther you will jump. The present study indicates a rate of improvement of 8 cm per 0.1 m/s increase in run-up speed. A long jumper may improve his run-up speed by using a better running technique or by increasing the strength of the muscles used in sprinting (or by a combination of the two). We contend that the trend from the technique intervention study indicates the improvement to be expected solely through better running technique. Note that the intervention study considers a single athlete with a unique combination of body size, muscular strengths, and technical proficiency. The trend line for this athlete indicates the expected improvement if all these characteristics are unchanged, except that the athlete is able to produce a faster run-up speed. During the technique intervention study, the muscular strength of the athlete did not change, and so the trend line must therefore indicate the improvement to be expected through better running technique.

Strength Training: We also contend that Hay's trend line indicates the effect of muscular strength on long jump performance, rather than the effect of run-up speed. Recall that this study considers athletes of different ability. It is well accepted that athletes with stronger dynamic leg strength can run faster and can exert a greater force at takeoff (Young, 1995). We believe that the main cause of variations in ability among athletes is differences in muscular strength, rather than differences in body size or technical proficiency. That is, the performances in the upper right of Figure 1 (for the cross-sectional study) are produced by strong athletes who can therefore run fast and exert large takeoff forces, whereas the performances in the lower left are weaker athletes who cannot run as fast or exert large takeoff forces. Hay's trend line therefore indicates how an athlete's performance would change in response to a change in strength. Unfortunately, the trend line does not reveal the magnitude of the strength increase required for a given improvement in jump distance. The

relatively large scatter in the data about the trend line is a reflection that body size and technical proficiency also have an important influence on an athlete's performance. Figure 2 shows the trend lines expected for a hypothetical series of technique intervention studies in which the athlete's muscular strength is systematically varied (body size and technical proficiency remain constant). As muscular strength increases, the athlete has a faster maximum run-up speed and so the upper limit of the trend line moves further to the right. In addition, the athlete is able to exert a greater takeoff force and so at any given run-up speed the athlete is able to jump farther. That is, the whole trend line is shifted upward.

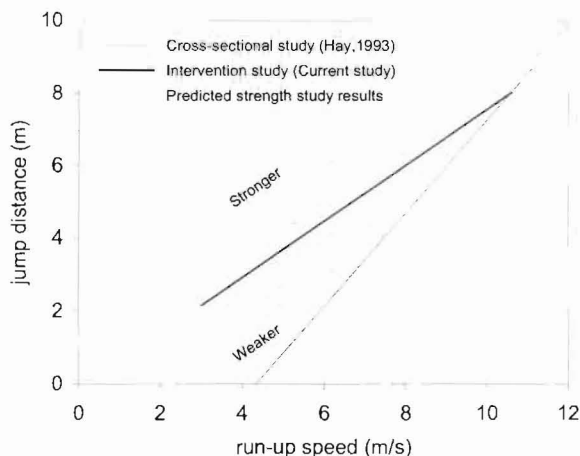


Figure 2. Predicted effect of strength on the results of a technique intervention study.

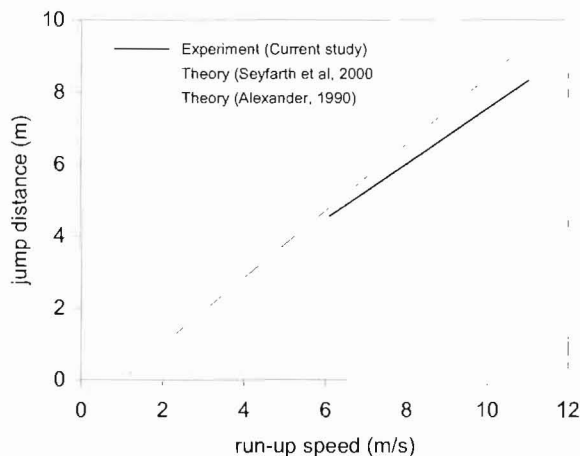


Figure 3. Comparison of experimental and theoretical studies of long jumping.

Theoretical Studies: The results from the theoretical models of Alexander (1990) and Seyfarth *et al.* (2000) were in good agreement with the experimental data from the technique intervention study (Figure 3). This suggests that the models, which consist of a two-segment mechanical model of the takeoff leg with a Hill-like torque generator at the knee, contain much of the essential features of a long jumper. These models may provide a means of

testing the predicted effects of muscle strength on long jump performance that are shown in Figure 2.

Wind Assistance: The trend line from the technique intervention study was used to calculate the effect of wind on a long jumper's performance. An athlete running with a tailwind experiences reduced air resistance and so is able to achieve a faster running speed. Linthorne's (1994) analysis of 100-m sprinters indicates that a 2 m/s tail wind increases an athlete's running speed by 0.10 m/s. Assuming a similar increase in long jump run-up speed, the improvement in performance for a 2 m/s tail wind is expected to be 8 cm. To this must be added to a 2 cm increase due to the effect of wind in the flight phase (Ward-Smith, 1985), giving a total increase of 10 cm.

CONCLUSIONS: Run-up speed has a strong influence on long jump performance and so speed training and strength training are essential components of a long jumper's training program. The use of results from cross-sectional studies may lead to inappropriate or inaccurate conclusions for the individual athlete. Data generated from intervention / longitudinal studies may be more appropriate for quantifying long jump performance.

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