DETERMINATION OF OPTIMUM HEEL INCLINATION FOR MAXIMUM HEIGHT VERTICAL JUMPS

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In order to provide better shock absorption, athletic shoe companies have increased the heel thickness, creating a positive heel inclination. Specifically, the heel inclination for most athletic shoes is about +4 degrees. This study, however, was based upon the hypothesis that increasing heel thickness may, in fact, contribute to a decrease in the athlete's performance. The purpose of this study, then, was to determine the effect of both negative and positive heel inclination on standing vertical jump height with the additional challenge of determining if an optimum heel inclination exists that will maximize jump height.

METHODOLOGY

Subjects

Eight female and five male Division I track and field athletes volunteered to perform standing vertical jumps. The subjects were specialists in various track and field events. Five of them were trained horizontal jumpers.

EQUIPMENT

All jumps were performed from a platform designed to allow for the possibility of a continous range of negative and positive degrees of heel inclinations. At the apex of their jumps, the subjects marked an over hanging chalked board with their finger.

PROCEDURE

Before testing, the subjects performed their usual warm up and during testing were given as many practice jumps as desired. In order to determinate each subject's standing reach, the subject stood on tiptoes. This procedure takes foot length into account in the execution of the jump.
The testing was conducted during one session; however, two series of jumps were used to collect the data. The objective of the first series was to determine the angle of inclination at which maximum height can be attained. During the first series, the subjects performed three vertical jumps using the Sargent Vertical Jump Test protocol under five conditions: +4,0, -2;-3, -4 degrees of inclination in that order. After all subjects performed the required number of jumps at a particular inclination, the platform was adjusted to the next inclination angle in the test sequence. Any obviously poor performance was discarded and the jump was repeated. The differential over their maximum standing reach was then recorded.
After the "optimum" angle of inclination was determined, a second series of jumps was performed using the optimum angle and the +4 angle. The subjects were again given 3 jumps at these two angles. +4 degree inclination with the determined optimum angle (if a difference existed) and **2)**

to determine the reliability of the data gathered in the first series of jumps.
Finally, the jump heights were adjusted to take into account the positioning of the toes above and below the horizontal as the angle of inclination changed.

STATICAL DESIGN

For both series of jumps, a one-way repeated measure ANOVA design was used. In the first series, 13 subjects jumped at 5 angles. in the second series, the same 13 subjects jumped at 2 angles.

RESULTS

The result of lowering the heel from an inclination of +4 degrees to -4 degrees in the first series of jumps in shown in Figure 1. The observed difference in jump heights between each angle was statistically significant, $F(4,48)=3.76$, $p<.001$. Figure 1 also shows an upward trend in jump height as the heels were lowered, except at -3 degrees. Formal F tests show, however, no significant difference between +4 and 0 degrees and between -2,-3 and -4 degrees.
The results in the second series of jumps comparing +4 to 3.5 is shown in Figure 2. The observed difference in jump heights was statistically significant, $F(1,12)=23.7$, $p<.001$. On average, the subjects increased their jump height by 2.7 cm when using a 7.9% increase. In fact, twelve of the thirteen jumpers showed an increase. Furthermore, the second series of jumps showed that the data gathered in the first series was reliable. In both series, the lowest heel inclination resulted in a marked improvement in jump height over the +4 angle.

DISCUSSION

The following questions have emerged from this study:

1. What is the actual jump height versus angle relationship? We suspect a continous upward trend peaking at about -3.5 degrees.
   However, this has not yet been sufficiently verified by our data.

2. Is there an optimum angle or does it differ for different jumpers?

3. Is there a training effect; i.e., with practice can one move to a more negative incline and thereby to a greater jump height?

4. What is causing the increase height?
   a) Is greater force being generated as a result of stored elastic energy, or
   b) Is it longer foot contact time that thus allows for greater impulse, or,
   c) Is it some combination of the two?

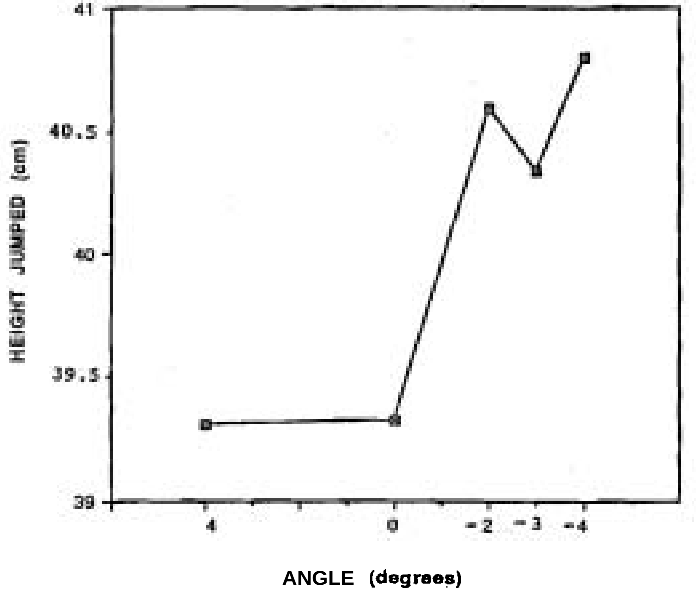

Figure 1. Jump Heights Attained at +4° to -4°: First Series

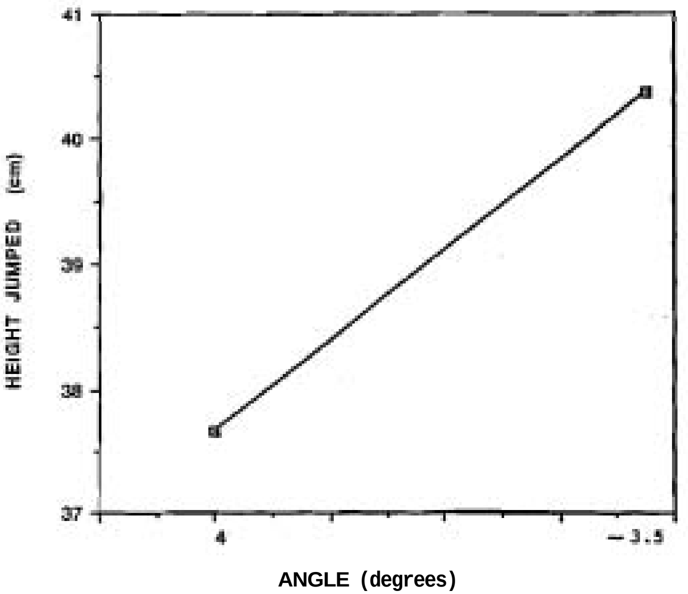

Figure 2. Jump Heights Attained at +4° and -3.5°: Second Series

CONCLUSION

Statical analyses of the data show that the angle of heel inclination does affect jump height, but these tests do not ascertain if an optimum exists. The results of these tests do suggest, however, that there is clearly an increase in jump height as the heel inclination is lowered from 0 degrees to any of the negative heel inclinations tested. What is clear, therefore, is that the toe-up angle results in an increase in jump height. The dip in jump height -3 degrees could be a result of chance variation, but it could also be the result of fatigue or inconsistency due to the number of inexperienced vertical jumpers who partipated in the study.

For the second series we wanted to compare the current shoe angle, +4 degrees with some optimum angle. Since the optimum angle, if one even exists, is not cleat from the data, we based our choice of -3.5 degrees on the observation that most of the subjects peaked at -3 or -4 degrees.