THE TNFLUENCE OF AN INCREASED TAKE-OFF ON MECHANICAL AND KINESIOLOGICAL VARIABLES IN HIGH JUMPING

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INTRODUCTION

During the training practice of high jumping, the increased take-off, usually from a piece of vaulting box, is frequently used. According to most of the trainers, the justification for the use of this help is, that especially the flight phase of the jump can be lengthened. Thus one can pay more attention to the technique of crossing the bar.

In this experiment the influence of this methodical expedient on mechanical and kinesiological variables of the take-off process is investigated and compared with the take-off from the ground. Based on these data the consequences of the load on the lower limbs and jump coordination is analysed.

METHODOLOGY

The take-off phases of seven experienced high jumpers were studied (national level). Their personal best marks varied between 2.00 and 2.21m (mean : 2.10 ± 0.08m). The average standing height was 1.88m ± 0.03m, and their average weight was 75,3 ± 3.3kg. The subjects were filmed in the sagittal plane with a NAC 400 High Speed camera (100 hz), performing maximal jumps with normal and increased take-off (height 0.29m).

The best 3 trials in each condition were selected for further analysis. After digitizing, the relative position of the markers of interest were determined with the DLT algorithm with two-dimensional calibration. The temporal raw data series (2 for each marker) were filtered with Cubic Splines. All variables were normalized in reference to the total contact time of the take-off phase. Because of the small number of subjects, statistical differences between the two conditions were tested with the non-parametric Wilcoxon test with a significance level $p \leq 0.05$.

The take-off phase was analyzed from two points of view : mechanical, where the body can be seen as one point, the center of gravity, and a kinesiological approach. In this approach attention is paid to the joint angles, joint angle velocity and radial velocities.

RESULTS AND DISCUSSION

Mechanical

TABLE 1 : Mechanical Variables during the take-off phase

N = 7; Mean ± SD		PLANE	INCREASED	WILCOXON
Contact Time	(s)	0.174 ± 0.011	0.180 ± 0.012	NS
▲ Vertical Velocity	($m.s^{-1}$)	3.96 ± 0.39	3.16 ± 0.30	$p < 0.05$
▲ Horizontal Velocity	($m.s^{-1}$)	-2.99 ± 0.40	-2.83 ± 0.31	NS
▲ Height COG	(m)	0.39 ± 0.02	0.48 ± 0.03	$p < 0.05$
Maximum Height COG	(m)	1.99 50.13	2.03 ± 0.14	NS

Considering the height of the platform, the calculated maximum height of the center of gravity is on average 0.04m higher with the increased take-off (see Table 1). From this tendency to jump relatively higher with an increased take-off, one could expect that during this take-off a larger force is being developed. In contrast with this expectation we experienced a distinctively larger linear impulse in the plane condition (plane : 3.96 ± 0.39 $BW.m.s^{-1}$; increased : 3.16 (0.30 $BW.m.s^{-1}$; $p < 0.05$). The explanation can be found in the fact that the vertical take-off velocity is not built-up in the same way in both conditions. In the plane condition, the center of gravity has a slightly negative velocity (-0.27 ± 0.18 $m.s^{-1}$) during the placing of the take-off foot which, during the take-off, must be converted in a positive vertical velocity, which should be as high as possible. In the increased condition the athlete already has a positive vertical velocity (0.63 ± 0.10 $m.s^{-1}$) during the placing of the take-off foot, because he has to put his foot on the platform. The vertical velocity is built-up in two phases : a preliminary take-off of the free leg and a real take-off.

A slightly larger change in horizontal velocity was measured in the plane condition. Together with the phenomenon of the preliminary take-off, this confirms the hypothesis that in the plane condition the extensors are heavier loaded eccentrically.

Kinesiological

In this approach, attention is paid to the radial velocity of the hip (i.e. the velocity with which the hip joint moves towards the take-off foot) as being the most important variable to determine the eccentric and concentric phase of the take-off (Dapena & Chung, 1988). If there is a negative radial velocity, the extensors are eccentrically loaded. This process is caused by the slowing down of the horizontal velocity and the movements of the free limbs (the arms and the free leg).

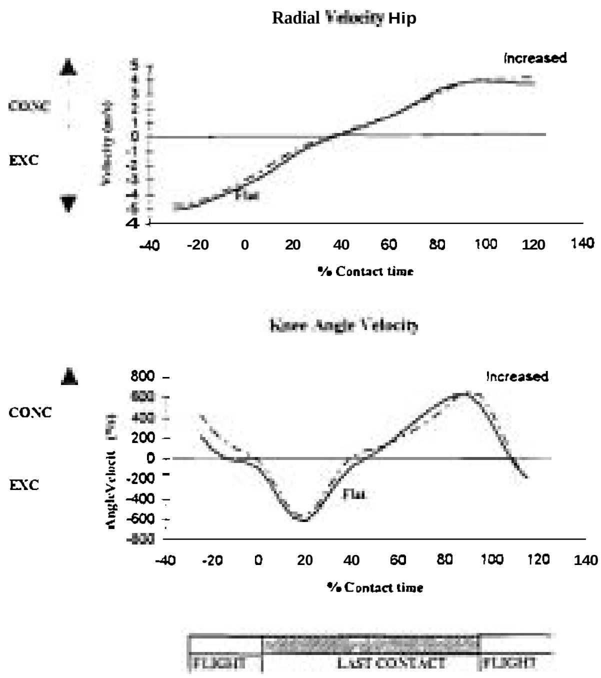

FIGURE 1 : Temporal evolution of the radial velocity of the hip and the knee angle velocity during the take-off phase
Mean curve of 7 persons

Fig 1 indicates a tendency for larger negative values for the radial velocity of the hip, during the eccentric phase of the take-off in the normal condition (-3.33 ± 0.36 $m.s^{-1}$; increased : -3.02 ± 0.25 $m.s^{-1}$; NS). A similar tendency appears in the path of the knee-angle velocity (fig 1b). In the plane condition, more extreme values can be found eccentric (maximum flexion velocity: normal : -621 ± 78.8 $degrees.s^{-1}$; increased : -581 ± 32.3 $degrees.s^{-1}$; NS) as well as concentric (normal : 413.4 ± 112.7 $degrees.s^{-1}$; increased : 315.1 ± 71.6 $degrees.s^{-1}$; $p \leq 0.05$). This indicates that the extensors are pre-strained, for more explosive contractions.

A second phenomenon is that the knee-angle velocity becomes positive at a later stage during the plane condition. In other words the eccentric load is not only increased, but lasts even longer (in the plane condition the values become positive after 40% of the contact time compared to 35% with the increased take-off). An important consequence of this observation is that the jump coordination is altered by the use of an increased take-off.

A third observation is the transition of eccentric (knee-bending) to concentric which occurs (knee-extending) fluently in the plane take-off, while with the increased take-off the knee remains flexed for a rather long period (30ms). This could point to a more efficient use of the stored elastic energy in the plane condition.

The radial velocity of the free limbs behaves in the same way : more extreme values are shown in the plane condition. This fact contributes to the thesis of heavier eccentric and concentric load in the plane condition.

Individual Differences

Most athletes profited from using an increased take-off platform. The extremes are athlete 4, who jumps 0.15m less high with the use of a platform and athlete 6, who jumps 0.22m higher. These individual differences do not only appear in the maximum flight height, but also in the time aspects of the jump coordination: with athlete 4 a very clear flat appears in the transition from concentric to eccentric knee-angle velocity. With athlete 6 an immediate transition is seen.

CONCLUSION

- There is a tendency for a larger maximum height of the center of gravity, when jumping with an increased take-off.
- With the increased take-off probably a smaller load of the take-off leg occurs, as a result of the preliminary take-off, by which the vertical velocity is built-up in two stages.
- Large individual differences occur between athletes probably due to familiarity with the method.
- In practice, the lower load of the take-off leg favours an increased take-off. This method can be used to learn the technique of barcrossing, and also for teaching young athletes and rehabilitating jumpers. A negative feature of the increased take-off is the disturbance of the jump coordination.

  As a general conclusion we can state that the application of an increased platform has its advantages but should not be used frequently.

REFERENCES

Dapena, J., & Chung, C. (1988). Vertical and radial motions of the body during the take-off phase of high jumping. Medicine and Science in Sports and Exercise, 20, 3, 290-302.