EFFICACY OF A MINI-TRAMPOLINE PROGRAM FOR IMPROVING THE VERTICAL JUMP

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INTRODUCTION

Many athletes seek to jump higher. Typical training programs consist of resistive exercises such as plyometrics or weight training. For example, Chu (1992) recommends the plyometric exercise of drop jumping or depth jumping. Drop jumping can increase vertical jump height; however, improvement in vertical jumping due to drop jump training is widely varied and cannot be satisfactorily explained (Bobbert, 1990). In addition, plyometric training is quite stressful to the body and can produce substantial muscle soreness (Wilson, Elliott, & Wood, 1990). Thus, it is suggested that plyometric training should be added only after an athlete has established strength (Powers, 1996).

Strength training for jump sports usually consists of lifting weights for the muscles involved in jumping and/or performing Olympic lifts. These methods are accepted and widely used, yet in order to take full benefit of an increase in muscle strength, control needs to be adapted (Bobbert & Van Soest, 1994). That is, resistive exercises should be combined with or replaced by other exercises, such as repetitive jumping, that develop the technique of jumping. Such programs have been suggested for improving vertical jumps (Bobbert, 1990; Hudson, 1990).

Unfortunately, repetitive jumping may lead to injury from the cumulative trauma of landing (cf. Dufek & Bates, 1991). Repetitive jumping on the mini-trampoline, however, might minimize the trauma of landing and reduce the risk of injury. Moreover, the mini-trampoline might elicit skillful technique in jumping: First, good balance is critical to skillful jumping in that horizontal velocity must be minimized for vertical velocity to be maximized. Because the small, raised bed of the mini-trampoline offers a disincentive for jumping forward, a jumper may adjust balance automatically in order to keep sure footing. Second, better jumpers appear to use less range of motion in the crouch of the jump compared to their less skilled counterparts (Hudson & Owen, 1982). Given that part of the upward thrust in mini-trampoline jumping is provided by the recoil of the elastic bed, there is less need for the jumper to take a deep crouch. Third, skilled jumpers seem to use a more simultaneous pattern of intersegmental coordination relative to less skilled jumpers (Hudson, 1986). To be effective in jumping on the mini-trampoline, one cannot work asynchronously with the bed of the trampoline; this need to synchronize the body with the bed might lead to a relatively simultaneous intersegmental coordination. Presumably, if better technique is elicited by training with the mini-trampoline and this technique is carried over to jumping from the ground, the trainee will also jump higher.

Thus the purpose of this study was to test the efficacy of a repetitive jumping program on the mini-trampoline for improving the vertical jump. The first objective was to determine if jump height was increased after the training program. The second objective was to investigate changes in technique after the training program. Specifically, did subjects improve (a) balance by diminishing forward translation, (b) range of motion by reducing the depth of the crouch, and (c) coordination by minimizing asynchronous movement?

METHODS

An intact group of 8 female intercollegiate basketball players (age=20.2 yrs, height=173.1 cm, mass=72.1 kg) volunteered for this study at the conclusion of their competitive season. The subjects participated in a mini-trampoline jumping program in addition to their normal post-season regime of maintenance weight lifting and basketball scrimmaging. The jump-training program consisted of 12 sets of 5 repetitive jumps on a mini-trampoline twice a week for 5 weeks, Subjects were encouraged to produce maximal effort, but were not verbally coached on any of the variables of this study. Compliance with the jump-training program was good, and all subjects completed a minimum of 500 jumps.

Maximal vertical jumps were analyzed before and after the training program. Jump height was measured in the gymnasium on a Vertec vertical jumping apparatus. Because of the overhead target, these jumps are similar to those demonstrated in game settings. Technique was assessed from jumps which were performed the following day in the lab. Again subjects were asked to jump maximally, but the overhead target was imaginary. Reflective markers were placed at estimated joint centers, and the right side of the subject was videotaped. For each subject, a representative trial from both before and after the training program was selected for analysis.

The 16 selected trials were digitized with a Peak5 Motion Measurement System. After scanning for and interpolating outlying data points, each data array was smoothed with a Butterworth filter. Cut-off frequencies for each array were determined by the optimal option in the Peak software. Smoothed segmental end points and anthropometric data for females from Plagenhof et al. (adapted by Kreighbaum and Barthels, 1996) were used to calculate the center of gravity (CoG) of the body. Angular position for the knee joint and the trunk and shank segments relative to vertical were computed as were angular and linear velocities for each frame and trial.

Balance was represented by the horizontal velocity of the body's CoG at takeoff (Hudson, 1996). Range of motion was indicated by the knee angle at deepest flexion (Hudson & Owen, 1982). Coordination was operationalized as the shared positive contribution (SPC) of the thigh and shank segments (Hudson, 1986). That is, each segment was considered to be actively contributing to the thrust of the jump if its angular velocity was above zero and increasing. The number of frames in which both segments were active was divided by the number of frames that either segment was active to determine the percentage of SPC. The before- and after-training results were compared with a dependent group t-test interpreted at the .05 level of significance.

RESULTS AND DISCUSSION

Group means for the jumping variables before and after the training program are given in Table 1. Jump height on the Vertec ranged from 34.3-41.5 cm before training and from 35.6-45.7 cm after training. Six of the 8 subjects increased jump height by an average of 4.5 cm, and 2 subjects increased jump height by 6.3 cm. The mean increase of 3.3 cm in jump height was significant. Thus, it appears that the mini-trampoline program was effective for increasing the height of the jump. It is possible, however, that certain individuals may not benefit from such a program. For example, the subject who was considered the most skillful jumper at the outset of the study did not change jump height, and the subject with the highest jump decreased jump height after the training program.

Table 1. Means and Standard Deviations of Jumping Variables Before and After the Training Program

	Jump Height*	Horiz. Velocity*	Knee Flexion	SPC
Before	37.7 ± 2.9 cm	13.3 ± 20.1 cm/s	102.5 ± 9.7°	82 ± 14%
After	41.0 ± 3.5 cm	-15.5 ± 8.9 cm/s	104.9 ± 4.8°	85 ± 6%

* p<.05

In terms of balance, 7 of the 8 subjects exhibited positive horizontal velocity of the COG at take-off and traveled forward before the training program. The exception was the most skilled subject who had a negative horizontal velocity of the CoG at take-off. After the training program, all 8 subjects exhibited negative horizontal velocity of the CoG at take-off. This change in balance from the beginning to the end of the training program was significant and consistent with the expectation that forward translation would be reduced after jumping on the mini-trampoline. A broader interpretation of these results is limited by the fact that balance is rarely measured in vertical jumping studies. However, the present velocities are similar to but larger than the velocities reported for an intermediate jump shooter, -5 cm/s, and an advanced jump shooter, 0 cm/s (Spina, Cleary, & Hudson, 1996). Combining the results of these two studies the following hierarchy of skillfulness for balance in vertical jumping is proposed for relatively experienced adults: (a) excessive positive horizontal velocity, (b) excessive negative horizontal velocity, and (c) little or no horizontal velocity in either direction.

Range of motion, as indicated by knee flexion in the crouch, varied from 87.2-120.9" before the training program and from 99.0-114.6° after the training program. Individual results are displayed in Figure 1. Six of the 8 subjects decreased their knee flexion after the training program, but for 2 of them the change was less than .5°. The subject with the most knee flexion made the greatest change (87.2-101.0") and the subject with the least knee flexion made the second greatest change (120.9-114.6°). Only the subject with the most skill did not change (106.7"). Also, the subject who decreased jump height was the only subject to have a knee angle of less than 100" after the training program. Statistically the mean decrease of 2.4° in range of motion was not significant. One explanation is that the mean knee flexion before training was in the desirable range of 90-110" suggested by Knudson and Miller (1997), so a change might not be needed. Another explanation is that the t-test is not sensitive to non-linear trends in the data. With the exception of the subject whose jump height decreased, all of the other subjects had knee flexion angles converging around 105-110° after training. That is, the subjects whose range of motion was deeper than the convergence zone, decreased range of motion; those who were in the convergence zone did not change; and the subject whose range of motion was shallower than the convergence zone, increased range of motion. Given that most of these subjects had knee angles below the convergence zone before training, there was a general trend toward less knee flexion or shallower crouching after the training program. This trend was in keeping with the expectations for training on the mini-trampoline, but such training may be most efficacious for jumpers with a deeper range of motion in the crouch of the jump.

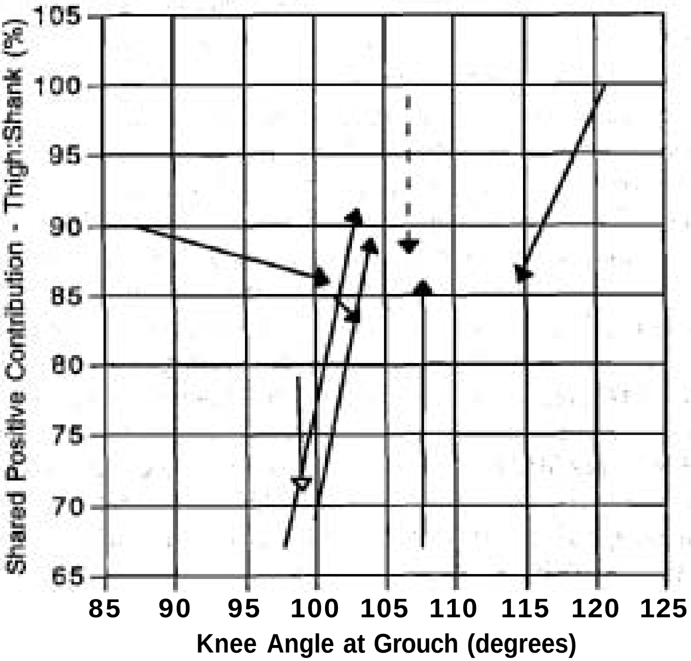

Figure 1. Each arrow depicts the results for one subject on coordination and range of motion. The tail and tip of the arrow indicate the before- and after-training results, respectively. The closed arrows with solid lines represent subjects who increased jump height, the closed arrow with a dashed line represents the subject who did not change jump height, and the open arrow represents the subject who decreased jump height.

Shared positive contribution of the thigh and shank, a measure of intersegmental coordination, ranged from 67-100% before the training program and from 71-88% after the training program. As seen in Figure 1, the 3 subjects with the Lowest SPC before the training program increased SPC by about 21% after the training program, and the 2 subjects with the highest SPC before the training program decreased SPC by about 13% after the training program. The subject who decreased jump height also decreased SPC from 79-71% after the training program. For the other 7 subjects SPC converged around 80-90% after training. The mean increase of 3% in SPC after training was not significant. Not much change would be expected, however, given that the SPC mean before the training program was the same as the mean for the most skilled subjects in Hudson's (1986) study. Although several subjects changed SPC by 10-20% after training, the before- and after-training means were similar because, once again, there was a non-linear convergence. Nevertheless, the average subject as well as the 3 most asynchronously coordinated subjects had an increase in simultaneity after the training program. Again, the subjects most likely to achieve the expected benefit in coordination from training on the mini-trampoline were the ones who seemed most in need of the benefit.

Although this study was quasi-experimental and causation of results cannot be established, there are some encouraging trends. Six subjects made impressive gains in jump height after the training program; all of them ceased jumping forward, and each of them maintained or manipulated range of motion and coordination toward the convergence zones of 105-110° and 80-90%, respectively. The most skilled jumper before the training program maintained good results for balance, range of motion, and jump height although her SPC diminished 12% into the convergence zone. For some reason, the subject with below average knee angle and SPC chose to maintain her range of motion and decrease her coordination after the training program; her jump height decreased as well.

CONCLUSIONS

The mini-trampoline appears to be an effective apparatus for increasing the height of the vertical jump. Also, the mini-trampoline seems to elicit better technique from many individuals: In terms of balance, there was significantly less forward translation in the jump. Range of motion, as indicated by knee flexion in the crouch, decreased for most subjects. And the coordination of the thigh and shank was relatively simultaneous after the training program.

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