PRE-ADOLESCENT STANDING JUMPING TECHNIQUES

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The standing vertical and standing long jumps both rise from a common origin, namely the stationary vertical upright position (Wickstrom, 1983). Dissimilar performance objectives, however, differentiate the two jumps. The direction of thrust is vertically upward for the vertical jump and horizontally forward for the long jump. Similarities between the standing long jump and the standing vertical jump have been suggested by Hellebrandt, Rarick, Glassow, and Carns (1961). Specific quantitative data to support or refute the suggestion of similar characteristics should provide beneficial information to the practitioner for instructional purposes. The purpose of this study, therefore, was to compare jumping techniques of pre-adolescents as they performed two standing jumping patterns that had different performance objectives.

METHODS

The subjects of this investigation were 49 sixth grade students who were enrolled in a Greensboro, North Carolina, elementary school during the spring of 1984. The subjects ranged in age from 11-13 years. All subjects participated in physical education classes on a weekly basis. Any extracurricular physical activities engaged in by the subjects were not monitored. Subjects signed consent forms that were co-signed by their parents.

All subjects were requested to perform three standing vertical jumps for maximum height and three standing long jumps for maximum horizontal distance. All three trials per subject per jump were videotaped but only the second trial was filmed. The standing long jump was performed on a standard gymnastics mat with an arbitrary takeoff point. The standing vertical jump was performed as the subjects reached for a stationary target. The target was a volleyball suspended by a hanging device at a height relative to each subject's maximum jumping height.

The sagittal view of the second trial of each jump was filmed with a 16 mm LOCAM camera operating at a film transport speed of 100 fps. The camera was located 5.08 m from the subject's right side. The film records were projected onto a horizontal surface with a Lafayette motion picture analyzer. Nineteen segmental endpoints were digitized with a Numonics 1224 digitizer interfaced to an Apple IIe microcomputer and further analyzed with software written by Richards and Wilkerson (1984). Consecutive frames were digitized beginning with several frames before the start of the concentric (propulsive) movement for both jumps. Digitizing ended with five to eight frames after takeoff in the standing long jump and two to three frames after reaching peak vertical height in the standing vertical jump. The raw data were smoothed with a second order low pass digital filter set at 6 Hz (Winter, 1982). The kinematic variables analyzed were: (a) jumping performance measures in the standing vertical and long jumps, (b) maximum knee flexion during preparation, (c) maximum descent displacement, (d) time spent in concentric (propulsive) phase, (e) angles of takeoff and linear velocities at takeoff, (f) maximum trunk flexion relative to the horizontal, and (g) range of motion at the hip relative to the trunk and thigh segments.

RESULTS

Forty-nine sixth grade students (22M, 27F) were the subjects of this investigation. Mean heights and weights ($\pm$sd) were 151.53 cm $\pm$ 7.86 and 43.82 kg $\pm$ 7.69 for the males and 153.65 cm $\pm$ 9.12 and 45.60 kg $\pm$ 10.79 for the females. Non-significant differences ($p > .05$) were revealed when independent t-tests compared the heights and weights of the subjects by gender. The results of this investigation, therefore, will be presented relative to the type of jump performed (i.e., vertical jump or long jump) irrespective of gender.

Vertical distance jumped was determined by measuring the vertical displacement of the center of gravity from takeoff to its highest vertical position. Mean vertical displacement for all subjects was 19.97 cm $\pm$ 5.20. Horizontal distance jumped was determined by measuring the displacement from the toe of the most forward foot at takeoff to the heel of the closest foot at landing. Mean horizontal displacement for all subjects was 140.24 cm $\pm$ 22.95.

Mean values for time spent from the point of maximum descent until takeoff (i.e., during the concentric or propulsive phase) were .208 s $\pm$ .046 for the vertical jump (VJ) and .236 s $\pm$ .054 for the long jump (LJ). The angle of takeoff was defined as the angle formed by the center of gravity and the toe of the foot closest to the camera relative to the right horizontal. The mean angles of takeoff were 87.41° $\pm$ 1.91 for the VJ and 56.63° $\pm$ 4.30 for the LJ. Mean takeoff linear velocities of the center of gravity were 2.062 $m \cdot s^{-1}$ $\pm$ .31 for the VJ and 2.639 $m \cdot s^{-1}$ $\pm$ .33 for the LJ.

Mean maximum knee flexion angles during preparation were 98.39° $\pm$ 9.08 for the VJ and 97.78° $\pm$ 8.28 for the LJ. Maximum descent was defined as the consensus point of maximum knee flexion, deepest hip descent, and deepest descent of the center of gravity. Depth of descent was defined as the vertical displacement of the center of gravity from maximum descent to takeoff. Mean depths of descent of the center of gravity were 32.19 cm $\pm$ 5.30 for the VJ and 25.82 cm $\pm$ 4.63 for the LJ. The depths of descent were comparable when the forward lean of the body at takeoff in the standing long jump was considered in comparison to the more vertical position of the body at takeoff in the standing vertical jump.

The maximum angle of trunk flexion relative to the horizontal was 63.06° ± 8.88 for the VJ and 26.85° ± 8.81 for the LJ. The range of motion at the hip relative to the trunk and thigh segments during the concentric phase was 67.46° ± 12.96 for the VJ and 98.16° ± 13.65 for the LJ.

Dependent t-tests revealed non-significant differences ($p>.05$) between the standing vertical and long jumps for the kinematic variables of the mean maximum angle of knee flexion and mean maximum depth of descent of the center of gravity. Recall that depth of descent for both jumps was defined as the position of the center of gravity relative to forward body lean at takeoff.

Dependent t-tests revealed significant differences between the standing vertical and long jumps for the kinematic variables of time spent in the concentric (propulsive) phase ($p<.007$), angle of takeoff ($p<.0001$), and linear velocity at takeoff ($p<.0001$). Significant differences ($p<.0001$) were also revealed for the variables of maximum trunk flexion relative to the horizontal and range of motion at the hip relative to the trunk and thigh segments.

Pearson product moments were computed to evaluate the relationships between selected pairs of variables. A positive linear relationship was revealed between the distance jumped vertically and horizontally ($r=.59$). As expected, linear takeoff velocities were positively related to both vertical distance jumped ($r=.65$) and horizontal distance jumped ($r=.67$). It was of interest, however, that the depth of descent in both jumps was positively related to range of motion at the hip relative to the trunk and thigh segments ($r=.53$, $r=.57$) and time spent in propulsion ($r=.55$, $r=.65$) for the standing vertical jump and the standing long jump, respectively. An inverse relationship ($r=-.64$) was revealed between angle of takeoff and horizontal distance traveled in the standing long jump.

DISCUSSION

A positive relationship was revealed ($r=.59$) between the vertical and horizontal distances jumped. This result would seem to support Wickstrom's (1983) suggestion that common elements exist between the two jumps despite their different performance objectives. Indeed, the sequence of movements used during the two jumps appear to be very similar. Both jumping skills are initiated by a flexion of body segments during their respective preparation phases and followed by a propulsion phase that is initiated by a vigorous downward and upward lift of the arms and a forceful extension at the hips, knees, and ankles. Qualitative inspection of the arm action utilized by the subjects of this investigation during the performance of the two jumps revealed similar arm patterning within the subjects across jumps until the time of takeoff. Non-significant differences ($p>.05$) between the two jumps were also reported for the kinematic variables of maximum knee flexion and maximum depth of descent of the center of gravity relative to forward body lean at takeoff. These results tend to support the suggestion that similarities exist between the two types of jumps.

Pearson product moments revealed similar relationships between selected kinematic variables within the two jumps. As expected, takeoff velocity was related to distance jumped ($r=.65$ for VJ, $r=.67$ for LJ). Depth of descent was found to be related to the range of motion at the hip relative to the trunk and thigh segments ($r=.53$ for VJ, $r=.57$ for LJ) and time spent in the concentric phase (r=.55 for VJ, r=.65 for LJ). These similar relationships further suggest that similarities do exist between the movement characteristics of the two jumping skills.

Significant differences between the two jumps were revealed, however, for range of motion at the hip relative to the trunk and thigh segments ($p<.0001$), maximum trunk flexion relative to the horizontal ($p<.0001$), and time spent in the concentric phase ($p<.007$). Increased trunk flexion during the execution of the long jump ($M_{LJ}=26.85^{\circ}$, $M_{VJ}=63.06^{\circ}$) appeared to accompany increased range of motion at the hip relative to the trunk and thigh segments ($M_{LJ}=98.16^{\circ}$, $M_{VJ}=67.46^{\circ}$) and increased time spent in the concentric phase (M_{LJ}=.208 s, M_{VJ}=.236 s). Additionally, significant differences were noted between the angle of takeoff ($p<.0001$) and linear velocity at takeoff ($p<.0001$). It appears, therefore, that greater trunk flexion and range of motion are associated with lower takeoff angles ($M_{LJ}=46.56^{\circ}$, $M_{VJ}=87.41^{\circ}$) and increased linear takeoff velocities in the standing long jump ($M_{LJ}=2.639\ m\cdot s^{-1}$, $M_{VJ}=2.062\ m\cdot s^{-1}$).

The inverse relationship (r=-.64) revealed between takeoff angle in the long jump and horizontal distance jumped suggests that lower angles of trajectory appear to be related to increased distance jumped. Increased takeoff angles result from an increased vertical velocity relative to horizontal velocity at takeoff. The mean angles of trajectory reported for the standing long jump ($M=56.63^{\circ}$) were higher than those reported by Henry (1948) of 41.3° for college males. The higher takeoff angles for the standing long jump suggest that the majority of subjects in this investigation were not executing a mature standing long jump. Conversely, the mean angle of trajectory reported for the vertical jump ($M=87.41^{\circ}$) did appear to represent a mature jumping pattern since the linear takeoff velocity was dominated by its vertical velocity component relative to its horizontal component.

CONCLUSIONS

The results of this study seem to support Wickstrom's (1983) developmental theory that commonalities not only exist between the two jumping skills but that the standing long jump evolves from the vertical jump. It would appear that the subjects of this investigation exhibited more mature jumping patterns in their vertical jumps than in their long jumps. An inspection of the variability in performance revealed less variability in the mean angle of takeoff for the vertical jump ($M=87.41^{\circ} \pm 1.91$) than for the long jump ($M=56.63^{\circ} \pm 4.30$). Less variability exhibited in the vertical jump suggest that the subjects were at similar developmental levels in the vertical jump, where as the increased variability in the long jump suggest that the same set of subjects were at different developmental levels in the long jump. As the standing long jump develops, therefore, it seems to progress from a predominantly vertical projection toward one that involves increased risk taking on the part of the jumper by shifting the center of gravity forward from within the base of support. This increase in risk taking results in increased horizontal projection. The angles of projection for the standing long jump, which were higher than those reported in the literature for adult males, might also support this contention that all subjects were not able to take this risk.

Distinguishing differences noted between the two jumping skills offer information that could be used by the practitioner in the instructional setting. This information might aid in refining the desired results of a skill based on the primary objective. If horizontal distance is the primary objective in a jumping skill, the results of this study suggest that increased degree of trunk flexion relative to the horizontal and increased range of motion at the hip relative to the trunk and thigh segments should be emphasized. These two actions appear to increase the performer's ability to displace the center of gravity from within the base of support in a forward direction prior to takeoff.

Since the present sample included subjects that appeared to have not yet perfected the execution of a mature standing long jump, additional research involving subjects with more mature patterns would provide valuable information relative to similarities and dissimilarities between the two jumping skills. It is suggested that further study comparing segmental coordination patterning between the two jumping skills be pursued. Such research should provide additional information relative to similarities and dissimilarities exhibited by performers in the execution of the standing long jump and the standing vertical jump.

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