A COMPARISON OF THE EFFECT OF TRANSFERRING MOMENTUM FROM THE PART TO THE WHOLE IN THE VERTICAL JUMP AND THE STANDING LONG JUMP

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The transfer of momentum is frequently observed in physical performance e.g., in the track start a track athlete thrusts an arm forward to start quickly down the track. a pulling lineman pulls the arm horizontal to the ground to turn the body in the direction of the run, a discus' thrower throws the off arm backward to transfer momentum to the discus, a long jumper throws the arms upward at takeoff to transfer momentum to his body, a high jumper throws arms upward when leaving the ground to transfer momentum upward to go over the bar, a gymnast throws both legs upward in performing a kip up on the horizontal bars, and at center jump in basketball, the jumper thrusts both arms upward to transfer momentum to the whole body. Greater force may be obtained by integrating the momentum that was initiated by one body part and transferring it to another. Most books in biomechanics address the principle of transferring momentum from the part to the whole, yet little research could be found in the literature addressing how great this effect might be.

The purpose of this study was to compare the effect of transferring momentum from the part to the whole in the vertical jump and the standing long jump.

More specifically it was the purpose of this study to:

1. Determine the percent of the vertical jump and the standing long jump attributed to leg production and to the transfer of momentum.
2. The relationship between performance in the vertical jump and the standing long jump.
3. Compare leg production in the vertical jump with leg production in the standing long jump.
4. Compare transfer of momentum in the vertical jump with transfer of momentum in the standing long jump.

METHODOLOGY

Thirty-one college male physical education majors who possessed athletic experience were subjects for this study. Average height and weight values for this group were 1.80 meters (SD = ± .0930m) and 85.13 kg (SD = ± 14.26 kg).

Each subject was asked to jump with arms pointing straight down throughout the jump. Subjects were to jump as high as possible on each jump. Measurement was taken to the top of the head on the highest of three jumps. Each subject's height was later subtracted from the highest jump to measure leg production on the jump.

On the next phase of the study each subject was to jump as high as they could using their arms to transfer momentum upward, bringing their arms to their side as the highest point was reached. The height of the top of their head was measured on the best of three jumps. Height was later subtracted from the best jump to measure leg production plus transfer of momentum.

Subjects were then asked to perform a standing long jump under two conditions. First, each subject stood behind a line and long jumped as far as they could with their arms pointing straight down throughout the jump. Measurement was made from the line to the closest heel on landing. This was used as a measure of leg production. During the next phase each subject was asked to jump as far as possible but this time they were allowed to transfer momentum using their arms. Measurement on each of three jumps was taken from the line to where the closest heel landed. The best of the three jumps was recorded. This was a measure of leg production plus transfer of momentum.

Mean, standard deviation, standard error of the mean, variance, and Pearson correlation coefficients were determined by SAS for height, weight, standing broad jump without arms, standing broad jump with arms, standing broad jump difference, vertical jump hands down, vertical jump hands up and down, and vertical jump difference. The difference between transfer of momentum in the vertical jump and transfer of momentum in the standing long jump was determined by the t-test.

RESULTS AND DISCUSSION

In comparing performance in the vertical jump with performance in the standing broad jump it may be seen in Table 1 that the mean vertical jump was .572 m with a standard deviation of ± .0815 m and a standard error of ± .015 m. Mean performance in the standing broad jump was 2.483 m with a standard deviation of ± .226 m and a standard error of ± .0406 m. A coefficient of correlation of .62 was found between the performance in the vertical jump and performance in the standing broad jump indicating that one who does well in the vertical jump will tend to do well in the standing long jump and one who does poorly in the standing long jump will tend to do poorly in the vertical jump.

Table 1

A Comparison of the Vertical Jump and The Standing Long Jump

	MEAN	SD	SE	r
VJ. (m)	0.57	f0.08	±0.01	.62
BJ. (m)	2.48	M.22	M.04	
L.P. (VJ.) (m)	0.47	f0.06	±0.01	.68
L.P. (L.J.) (m)	1.99	f0.19	M.03	
T.M. (VJ.) (m)	0.09	M.04	±0.01	.25
T.M. (L.J.) (m)	0.48	M.12	M.02	

V.J. - vertical jump; L.J. - long jump; L.P. - leg production;
T.M. - transfer of momentum

When comparing leg production in the vertical jump with leg production in the standing long jump it may be seen in Table 1 that the mean vertical jump without the use of the arms was .478 m with a standard deviation of ± .0660 m and a standard error of ± .012 m. Leg production in the standing long jump produced a mean of 1.999 m with a standard deviation of ± .199 m and a standard error of ± .0358. The coefficient of correlation between leg production in the vertical jump and leg production in the standing long jump was .68. A definite positive relationship exists between leg production in the vertical jump and leg production in the standing long jump.

When determining transfer of momentum affecting the vertical and standing broad jump, the distance jumped without the use of the arms (leg production) was subtracted from the distance gained with the use of the arms (leg production plus transfer of momentum). The difference gives the benefit derived from transfer of momentum of the arms to the whole body. As may be seen in Table 1, transfer of momentum in the vertical jump accounted for a mean of .0932 m in the vertical jump with a standard deviation of ±.0493 m and a standard error of ± .0089 m. In the standing long jump a transfer of momentum mean of .4841 m was obtained with a standard deviation of ± ,123 m and a standard error of ± .022 m. The relationship between transfer of momentum in the vertical jump and transfer of momentum in the standing broad jump was .25, a low but positive relationship. This relationship is lower than the leg production relationship between jumps probably due to the timing and coordination involved in the transfer of momentum and change of center of gravity in the body in the vertical jump as maximum height occurs.

Table 2 shows information that compares leg production and transfer of momentum production in the vertical jump and the standing long jump. Leg production in the vertical jump accounts for 84 percent of the vertical jump while transfer of momentum accounts for 16 percent of the jump while in the standing long jump, transfer of momentum accounts for 19 percent of the jump and leg production accounts for 81 percent of the jump. Transfer of momentum in the standing long jump was found to be significantly greater ($p<.01$) than transferring momentum in the vertical jump.

TABLE 2
A Comparison of Leg Production and Transfer of Momentum in the Vertical Jump and the Standing Long Jump

	Vertical Jump		Long Jump		p
	Mean (inches)	Percent of Max.	Mean (inches)	Percent of Max	
Leg Production	0.47	84	1.99	81	
Transfer of Momentum	0.48	16	0.48	19	.01

The reason that transfer of momentum accounts for a greater percent of total production in the standing long jump than in the vertical jump may be because there is a transfer of momentum forward as the arms are thrust forward while the feet are still in contact with the ground and as the arms are thrust backward while airborne just before landing. Therefore, the principle of transferring momentum from the part to the whole plays a more active role in the standing long jump than in the vertical jump.

CONCLUSIONS

Based on the results of this study it may be concluded that:

1. Leg production in the vertical jump and standing long jump accounts for a little over 80 percent of the jump.
2. Transfer of momentum in the vertical jump and standing long jump accounts for a little less than 20 percent of the jump.
3. There is a marked relationship between performance in the vertical jump and performance in the standing long jump.
4. There is a greater transfer of momentum in the standing long jump than in the vertical jump.