THE EFFECTS OF ARMS AND COUNTERMOVEMENT ON VERTICAL JUMPING OF FEMALES

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The purpose of the present investigation was to examine jumping parameters of female subjects performing four different jump techniques. Twelve subjects performed maximum vertical jumps using 4 techniques: countermovement jumps with and without use of the arms and squat jumps with and without the use of the arms. Force time data was collected using a Bertec force plate. Vertical ground reaction force, take off velocity, center of mass displacement after take off, impulse and power were calculated using the force time data. Analysis of the data indicated that use of the arms increased jump height more than the countermovement. Although most parameters measured in this study agreed with those previously reported for males there were some indication of gender specific differences with regard to jump height and use of arms and countermovement.

KEY WORDS: counter movement, jump technique.

INTRODUCTION: Jumping is an integral part of many sports. In most sports in which jumping is involved the jumps are preceded by a counter movement and arm swing to increase the vertical impulse and increase jump height. To date there has been much research done on various aspects of jumping (Harman et al. 1990). Relatively few of these studies use female subjects. Unless we assume that the important parameters and various measures related to jumping are the same for males and females there is a gap in the research regarding female jumping information. Differences between males and females that may affect jump parameters and performance include differences in upper body/lower body anthropometric proportions (Zatsiorsky, V., Seluyanov, V.,1983), Q angle, muscle fiber architecture (Chow et. al. 2000) and differences in upper/lower body strength proportions to name a few.
Greater lower body to upper body strength proportion differences would seem to imply that arm swing would play a lesser role in determining jump height for females. Mapping out gender differences in various jumping techniques could give us some insight to the possible mechanisms involved.
The purpose of this study is to measure important jump parameters of female subjects and compare these parameters to those previously reported for male subjects. The authors hypothesize that 1) arm swing will have a proportionally lesser influence on jump height in females that males and 2) the counter movement a greater proportional influence.

METHODS: Twelve physically active female subjects (mean and SD height: 168 +/- 8, body mass 62 +/- 10, age; 20 +/-0.5) jumped maximally from a force platform four different ways in random order counter movement with arms (CMA), counter movement without arms (CMNA), squat jump with arms (SJA) and squat jump without arms (SJNA). Each subject visited the lab one time several days before the measurement and was instructed how to perform each of the jumps. Each subject practiced the jumps on a force platform until they could perform the given jumps using the specified techniques. As anticipated the jumps requiring the most practice were the no counter movement jumps because of the body's natural tendency to perform a counter movement when attempting to jump maximally. On the day the jumps were recorded the subjects performed each jump maximally 5 times. The subjects were given enough rest so that they didn't feel any fatigue from the previous jumps. The start position for the CMA jumps was standing upright with the arms down at the side. For the CMNA jumps the subjects stood upright with their hands on their hips. For the SJA jumps the subjects started in a squat position with their arms at their sides and for the SJNA jumps they started in a squat position with their hands on their hips. No instructions were given with regard to the amount of knee bend a subject should have. All jumps were performed on a Bertec force platform with a data collection rate of 1004 Hz. All of the jumps for each subject were put into a file containing the jumps from all of

the subjects. The vertical ground reaction force (VGRF) was used to calculate vertical center of mass (CM) displacement, take off velocity and power values. The calculations were based on the principle that impulse equals change in momentum. The subjects mass was calculated using their weight as measured by the force plate. The change in velocity was calculated every 1/1004th of a second. Instantaneous power was calculated as the VGRF multiplied by the current velocity of the CM.
The jumps were then analysed for the group. T-tests were performed to identify significant differences between parameters of different jump techniques. Significance was set at $p<0.05$.

RESULTS AND DISCUSSION: The measured parameters are displayed in table 1. Minimum VGRF was similar during both types of counter movement jumps. Minimum VGRF was present in some of the squat jumps. Even after a previous day of instruction and a few warm up jumps some subjects had a hard time performing a SJ. Maximum VGRF was the greatest during the SJA jumps followed by the SJNA, CMA and CMNA jumps. It appears that both the use of the arms and the counter movement allow the jumper to increase the VGRF.

Table 1 Measured parameters (mean and SD) for counter movement jumps with (CMA) and without (CMNA) arms and squat jumps with (SJA) and without (SJNA) arms.

	CMA	CMNA	SJA	SJNA
Min GRF (N)	312 (135)^{3,4}	317 (129)^{3,4}	65 (29)	54 (25)
Max GRF (N)	706 (103)^{2,3}	658 (96)^{3,4}	762 (179)^{4}	736 (159)
Impulse (-) (Ns)	59 (24)^{2,3,4}	63 (20)^{3,4}	3.2 (1)	2.1 (2)
Impulse (+) (Ns)	207 (42)^{2,3,4}	198 (38)^{3,4}	141 (25)^{4}	127 (22)
Impulse at TO (Ns)	137 (23)^{2,3,4}	125 (20)^{3,4}	131 (22.5)^{4}	118 (21)
TO velocity (m/s)	2.17 (.14)^{2,3,4}	1.97 (.12)^{3,4}	2.07 (.15)^{4}	1.74 (.56)
Peak power (+)*(W)	1305 (240)^{2,4}	1082 (248)^{3}	1302 (323)^{4}	1167 (225)
Post takeoff CM rise (cm)	24.1 (3.2)^{2,3,4}	19.9 (2.4)^{3,4}	22.0 (3.2)^{4}	17.8 (3.5)
% CM rise of CMA	100%	83%	91%	74%

* Peak power was only calculated for each jumpers best jump for each technique. The superscript numbers(2,3,4) indicate significant differences between the columns of each given variable.

Peak power followed a different pattern than the other parameters. Although the SJNA jumps were markedly lower than the CMNA jumps, both jumps had similar measured peak power values. The peak positive power values of both the 'with arm' jumps were comparable.
The net negative impulse was considered the negative force x the time before the positive force started. The negative Impulse from when the force drops below body weight just before take off was not considered part of the net negative impulse. The net negative impulse was greatest during the CMNA jumps and negligible for the two squat jumps. For both the positive impulse and the total impulse before take off the highest values were for the CMA followed by SJA, CMNA and the SJNA. Accordingly, vertical TO velocity showed the same pattern as total impulse. For Positive impulse, total impulse and take off velocity significant differences were found between each group.
Up to this point the results of this study were the same general pattern as those previously reported for male subjects (Harman et al. 1990). One notable point was that the difference between the SJNA total impulse and TO velocity were proportionally less for the female subject when compared to the previously reported parameters of male subjects. This can be clearly seen in the vertical displacement values. As expected the vertical displacement of the CM after take off was greatest for the CMA jumps. For the subject group as a whole the SJA jumps had the next greatest vertical CM displacement followed by the CMNA jumps and then the SJNA jumps. These results indicate that the arms played a greater role in vertical CM displacement than the counter movement. When comparing the vertical post take off CM rise with previously reported values of male subjects there are some differences to make note of. When comparing the % CM rise of the CMA jumps with the other three techniques the percentages of

the vertical displacements are CMNA (83% of CMA post take off vertical displacement), SJA (91%) and SJNA (74%). The previously reported values for male subjects were 82%, 94%, and 78% respectively. These results show only a very slight tendency in the direction of our second hypothesis that the counter movement plays a proportionally greater role in female jumping performance than in male jumping performance. The most notable differences between the results of this study and previous reported results for males is the relative drop in performance for the squat jumps.

CONCLUSION: The results of this study indicate that the basic parameters during the four chosen jump techniques are for the most part similar between males and females. The exceptions are 1) a more pronounced decrease in jumping performance when performing squat jumps with no counter movement as compared to normal CMA jumps, and 2) a slight difference in the performance of the SJA and CMNA jumps as compared to the CMA jumps that might indicate a proportional difference in the benefit of the counter movement. Before this difference can be seriously considered more subjects have to be tested, preferably males and females measured by the same researcher. There is no indication from these results that show a lesser effect of arm swing on female jumping

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