DIFFERENCES BETWEEN JUMPING AND NON-JUMPING LEGS IN
DIVISION III COLLEGIATE TRACK AND FIELD JUMPERS

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ABSTRACT

Caldwell SC, Trench EM, Hoover JL, Bucheger NM. J. Undergrad. Kin. Res. 2006; 1(2): 1-7. This study compares the differences in balance, circumference, strength, and power. Subjects were 5 male and 4 female Division III collegiate track & field athletes. After a brief warm-up; the participants were tested in maximal thigh and calf girths, balance, one-legged vertical jump test, and one-legged one rep max press. There were no significant statistical differences in bilateral comparisons (p > 0.05) among any of the variables tested. The data suggests that there is not a significant difference of muscle imbalance and force characteristics for collegiate track jumpers. More research should be conducted using tests with higher functional value to jumping disciplines.

Key Words: Vertical, Balance, Power, Anthropometry, Dominant, Non-Dominant

INTRODUCTION

To the best of our knowledge there has never been a study done on physical characteristics and force production characters in jumping (J) and non-jumping (Non-J) legs, specifically collegiate track jumpers (high, long, and triple jumpers). In determining a way to study the differences, we referenced many journals that included bilateral leg comparison research. After researching peer reviewed journals it was decided to test bilateral leg comparisons of thigh and calf girths, strength, power, and balance in testing for possible muscle imbalances and effects that may lead to chronic orthopedic conditions.

In a training study done comparing isokinetic and isotonic exercise by Cordova et al.1 on the functional task a one-legged vertical jump test and comparing the respected ground reaction forces, showed that weight lifting strength gains made only a statistically small change in vertical jump ground reaction forces. The study revealed that isotonic strength gains (50% increase) showed an inverse relationship to one-legged jump reaction forces that showed only a small improvement (2.4%). Relating these results to collegiate jumpers raises the question whether or not strength differences are present and if so, do the vertical jump heights of a one-legged vertical jump bear a similar relationship between jumping and non-jumping leg performances, considering the jumping legs may have more neural balancing control and proprioception that may improve performance over the non-jumping leg. In our design we tested leg strength by a one-leg max using the leg press to determine the differences on J and Non-J leg strength, which on its own is
an important variable as well as an aid to the comparison of strength and power relationships.

Patterson and Peterson \(^2\) did a study in 2004 that concluded that vertical jump height is considered to be an important measure when evaluating leg power of various athletic groups. With that stated we used a one-legged vertical jump of both legs to determine leg power in collegiate jumpers. Vertical jump test allows the force character of power to be analyzed. Many experiments feature vertical tests, force plates that test ground reaction forces, or utilize both testing apparatuses. Due to a very strong relationship between ground reaction forces and vertical jump height, we are able to test power of each leg by conducting a one-leg vertical jump test on each leg without requiring a force plate for testing. Again, power is being tested as a result of the different training forces, mainly the chronic differences in load and unloaded jumping legs. Additionally, Liebermann and Katz \(^3\) used countermovement vertical jumps on a force plate in addition to left and right knee extensions to determine lower-limb muscular power capability, just as in our experiment the countermovement is used to increase the possible time for force production, which implements some level of functionality to competitive jumping.

In another study done on an elder population by Bean et al. \(^4\) power was found to have more accountability of completing Activities of Daily Life (ADL) than strength. Although a loose comparison between athletes and the elderly, relevance lies on the reliance of the power component of jumping rather than the strength of support leg when jumping. The jumping leg supports the load of the body over minimal time to propel horizontally or vertically compared to the non-jumping leg that unless triple jumping contributes little to contact force output and hence may have less leg power from less jumping loads and other functional loading associated with jumper’s training and programming.

Additionally, a balance component of jumping may play a factor into jumping and non-jumping leg performance. A study was done by Ageberg et al. \(^5\) involving single-limb standing balance. The study tested postural control while on a force-plate. Left and right-leg statistical data was merged due to finding no significant differences in balance and control between the two limbs. The study’s population was comprised of 24 subjects from a “normal,” population which could be assumed that “normal” populations are right leg-dominant in nature (just as right-arm dominant the majority) and did not have variance in dominant and non-dominant leg workloads or tasks, such to the elevated level that collegiate track jumpers experience. Assuming that balance may be different in collegiate jumpers, with basis on differences in jumping task loads, we tested balance and control of collegiate jumpers to see if a significant difference exists between J and Non-J legs. In addition, J legs are not necessarily assumed to be the dominant leg in our own study. So, dominance is not a defining characteristic of testing value for the specific nature of our study.

Lastly, peer reviewed journals were searched for leg and calf girth measurement studies that would give insight to potential bilateral differences. Although no previous studies featured girth measurements for similar purposes we felt it would be a reliable way in determining possible lean muscle mass differences. We assume lean muscle mass comparisons are possible because fat depositing is primarily thought to be symmetrical throughout the limbs.
This study was designed to determine differences of power, strength, size, and balance in collegiate jumpers between jumping and non-jumping leg. It’s hypothesized that there will be differences between power, strength, size, and balance between J and Non-J legs in collegiate jumpers.

METHODS

Participants
Men (n= 5) and women (n=4) collegiate jumpers participated in this study. The subject’s demographics are found in Table 1. Each subject signed an informed consent approved by the Institutional Review Board. Participants reported that they averaged exercising at moderate and vigorous intensities five times per week during the track and field season.

Table 1. Participant Demographics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
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</thead>
<tbody>
<tr>
<td>Age</td>
<td>19.33</td>
<td>±1.00</td>
</tr>
<tr>
<td>Height</td>
<td>178.05</td>
<td>±8.92</td>
</tr>
<tr>
<td>Weight</td>
<td>71.09</td>
<td>±8.30</td>
</tr>
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</table>

Procedures
All tests were done in the middle of the track season within two weeks of each other. Participant height and weight were recorded in shorts, t-shirt, and without shoes.

Leg Press Max
Using 1 RM-Testing protocol for the lower body found in Essentials of Strength and Conditioning we tested our subjects separate leg strength using the Hammer Strength-Isolateral Leg Press (ILLP). (Baechle 292).^6

1-RM Testing Protocol
1. Instruct Athlete to warm-up with a light resistance (5-10 rep2.s).
2. Rest for 1 minute.
3. Warm-up load for 3-5 reps by adding
   a. 30-40 lb. (14-18 kg) or 10-20% for lower body
4. 2 minute rest period
5. Estimate near maximum load for 2-3 repetitions by, again, adding:
   a. 30-40 lb. (14-18 kg) or 10-20% for lower body
6. 2-4 minute rest period
7. Load increase
   a. 30-40 lb. (14-18 kg) or 10-20% for lower body
8. Attempt 1-RM
9. If successful, 2-4 minute rest period and go back to step 7.
   If failed, 2-4 minute rest, and decrease load by:
   15-20 lb. (7-9 kg) or 5-10% for lower body
   And then go back to step 8.
   Continue until one repetition with proper technique. Ideally done within 5 testing sets.
Vertical Jump Test
Using the Vertec Jump Training System apparatus and the vertical jump test found in the text of Essentials of Strength and Conditioning, we tested our subjects’ vertical jump of each leg. Standing still the subject jumped up as high as possible slapping the wall or using the Vertec, pushing the vanes out at their peak (Baechle 293).

Circumference of Thighs and Calves
We used the procedure of Anthropometry to measure the girth of the calf muscles and the thigh muscles using a tape measure. We used the procedure found in Essentials in Strength and Conditioning. For the thigh we measured at the point of maximal circumference, usually just below the buttocks. For the calf we measured at the point of maximal circumference between the knee and the ankle (Baechle 304).

Balance Test
We used the Hoeger & Hoeger Balance test in which time was measured by the Seiko Model W073 stopwatch as the subjects stood on one bare foot with the other legs foot placed on the inside of the supporting knee with hands on hips. When the go command was given the subjects raised their heel off the ground (Hoeger 196). The test concluded when either the supporting foot fell, the raised heel touched the floor, the hands moved from the hips, or a minute had elapsed measured via a tape measure. (Hoeger 196).

Reliability
The vertical jump test is considered extremely reliable using this protocol. Test-retest reliability has been reported to range between 0.93 and 0.99. (Patterson and Peterson 35)

Statistical Analysis
A dependent paired t test was used to compare each leg of each individual.

RESULTS
There was no significant difference in balance between the jumping leg ($M=14.19$) and the non-jumping leg ($M=11.00$), $t (8) = 0.862$, $p > 0.05$, (Table 2). There was no significant difference in vertical jump between the jumping leg ($M=53.48$) and the non-jumping leg ($M=51.22$), $t (8) = 1.403$, $p > 0.05$, (Table 3). There was no significant difference in One-Rep Max between the jumping leg ($M=119.72$) and the non-jumping leg ($M=117.02$), $t (7) = 0.859$, $p > 0.05$, (Table 4). There was no significant difference in circumference of thigh between the jumping leg ($M=57.59$) and the non-jumping leg ($M=57.94$), $t (8) = -1.336$, $p > 0.05$, (Table 5). There was no significant difference in circumference of calf between the jumping leg ($M=36.11$) and the non-jumping leg ($M=36.61$), $t (8) = -1.134$, $p > 0.05$, (Table 6). There was no significant difference in power between the jumping leg ($M=16.07$) and the non-jumping leg ($M=15.65$), $t (8) 1.549$, $p > 0.05$, (Table 7).
Table 2. Vertical Jump

<table>
<thead>
<tr>
<th>Jump Height (cm)</th>
<th>Jumping Leg (J)</th>
<th>Non Jumping Leg (Non-J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>53.48 ± 11.77</td>
<td>51.22 ± 15.23</td>
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Table 3. Power

<table>
<thead>
<tr>
<th>Output (Watts × kg⁻¹)</th>
<th>Jumping Leg (J)</th>
<th>Non Jumping Leg (Non-J)</th>
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<tbody>
<tr>
<td>16.07 ± 1.81</td>
<td>15.65 ± 2.44</td>
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Table 4. One RM Leg Press

<table>
<thead>
<tr>
<th>Load (kg)</th>
<th>Jumping Leg (J)</th>
<th>Non Jumping Leg (Non-J)</th>
</tr>
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<tbody>
<tr>
<td>119.72 ± 29.52</td>
<td>117.02 ± 30.50</td>
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Table 5. Circumference Thigh

<table>
<thead>
<tr>
<th>Girth (cm)</th>
<th>Jumping Leg (J)</th>
<th>Non Jumping Leg (Non-J)</th>
</tr>
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<tbody>
<tr>
<td>57.59 ± 3.27</td>
<td>57.94 ± 3.39</td>
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Table 6. Circumference Calf

<table>
<thead>
<tr>
<th>Girth (cm)</th>
<th>Jumping Leg (J)</th>
<th>Non Jumping Leg (Non-J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>36.11 ± 2.04</td>
<td>36.61 ± 1.50</td>
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</table>

Table 7. Balance

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>Jumping Leg (J)</th>
<th>Non Jumping Leg (Non-J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.19 ± 8.95</td>
<td>11.01 ± 11.36</td>
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DISCUSSION

Based on the results of our study, we accept the null hypothesis. This study compared the physical and force characteristics of jumping and non-jumping legs and found no statistically significant differences in any of the variables tested. However, examining jumping distances and heights cleared, a difference of a mere centimeter, an otherwise insignificant difference in distance or height can determine winners and losers in jumping disciplines.

Probably most surprising of all variable tests was the vertical jump test, the most functional test to actual jumping disciplines. Means of jump heights were closer than expected (2.26cm) resulting in a mean relative power difference of only 0.42W/kg. These results suggest little difference in the power output of J and Non-J legs of jumpers. Additionally, the action of jumping has an approach of relatively high velocities with a sudden impact that causes a release of mechanical energy. Additionally, the impact of jumping causes elastic forces with increased dynamic stiffness within the leg muscle-tendon complexes and high stretch velocities. The vertical jump test as tested cannot simulate forces generated by such impacts and our results may not be able to analyze the possible maximal potential of the loaded J leg over Non-J legs. However, J legs saw higher correlation coefficients when comparing relative power to one rep max (r values of 0.682 for J to 0.599 of Non-J). We postulate that this may suggest a higher energy
transfer from strength to power in the J leg. However, it should be mentioned that slightly higher results of the vertical jump test may only be a result of J legs familiarity of jumping compared to the possible awkwardness or inexperience of Non-J loading and pushoffing off.

Strength tests results of the one rep max were insignificant, resulting in a mean difference of 2.7kg (119.72 - 117.02). The angle of the knee joint while performing the test was performed at a knee joint angle of 90° of flexion. While jumping (long jump) optimal takeoff angle found by Seyfarth et al. was found to be a leg angle of 65°-70° meaning knee angles are much greater and range of motion is much smaller than what the leg press ranges explored and tested through. Though, the one rep max test may not have been truly functional to jumping the test and results suggest little differences in leg strength even with the different chronic loading characters of jumping.

Girth measurements of thigh and calf were found to be very similar even measuring larger in the Non-J leg for the calf and thigh, which would suggest that lean muscle masses are similar and the elevated loading of the J leg does not equate to an increase in lean muscle mass.

The balance test was the closest to showing real statistical significance and may indicate that there is an increased balance training component in the loaded J leg. Results showed that the J leg scored 28% better when comparing means of the two legs. Although not significant, we assumed that heightened proprioception of J is again due to the chronic jump-training loads, the balance difference may be even higher if a dynamic balance could be tested in addition to the static balance test; however dynamic balance tests have been shown to have low validity.

CONCLUSION

In conclusion, we found no significant differences in comparing force, balance, and physical characteristics between the jumping and non-jumping legs of Division III collegiate track and field athletes in jumping (high, triple, and long). The findings of this study indicate that current training regimens do not have to be altered to achieve bilateral balance, even with the J leg having higher chronic loading forces.

ACKNOWLEDGEMENTS

We would like to thank the University of Wisconsin-Eau Claire’s track and field athletes for participating in our study.

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REFERENCES


