The Effects of the 5 Ballet Foot Positions on Spinal and Lower Extremity Posture

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Acknowledgments

- Subjects - female students from Baylor and Girls Preparatory School
- Dr. David Levine – study design and statistical analysis
- Dr. Michael Whittle – data collection
- Dr. Debbie Ingram - help recruiting subjects

Foot Positions

- First Position
  - stand with heels together
  - legs and feet are turned out (as close to 180°)
  - turn out from the hips as much as possible
  - do not let knees or ankles twist
  - arms held in front of the body with a slight bend in the elbow

- Second Position
  - from first position, slide feet away from each other
  - feet are still turned out (close to 180°)
  - there is about a foot-length (the length of your foot) in between the heels
  - both arms abducted to about shoulder height, with slight bend in elbow

- Third Position
  - place the heel of one foot against the middle of the other foot
  - keep both legs turned out
  - one arm is abducted to shoulder height; slight bend in elbow
  - opposite shoulder is flexed and slightly abducted with flexed elbow

- Fourth Position
  - from third position, slide the front foot forward
  - there should be about half of a foot-length between the two feet
  - keep both legs turned out
  - one arm is held in full shoulder elevation with slight elbow flexion
  - opposite shoulder is flexed and slightly abducted with elbow flexed
Foot Positions\textsuperscript{1,2}

- **Fifth Position**
  - place the outside of one foot against the inside of the other foot
  - feet should be toe-to-heel and heel-to-toe
  - both arms held in full shoulder elevation and slight elbow flexion

Turn-Out\textsuperscript{3-6}

- **Turn-out** is defined as external rotation of the lower extremities\textsuperscript{3}.
  - Achieved primarily at the hips to allow an ideal foot position of 180\textdegree.
  - Proper technique includes:
    - Hips externally rotated and augmented by external tibial torsion
    - A posterior pelvic tilt performed to decrease the amount of stress placed on the lumbar spine

Improper Technique\textsuperscript{3,4,7,8}

- Primarily a result of:
  - Insufficient hip external rotation leading to an increase in lumbar lordosis
  - Possibly increasing stress on lumbar spine, medial knee and/or ankles
  - Coplan et al found that 70\% of subjects exceeded passive hip external rotation in ballet positions
- Additional contributions:
  - Abdominal weakness
  - Tight lumbosacral fascia
  - Combination of both

Pelvic Tilt and Lordosis\textsuperscript{9}

- Levine & Whittle investigated the relationship between pelvic tilt and lordosis in normal standing among 20 females.
  - With anterior pelvic tilt, a significant increase in lordosis was found (p < 0.001)
    - Normal posture vs max anterior tilt – pelvic tilt increased 11.4\textdegree, lordosis increased 10.8\textdegree.
  - With posterior pelvic tilt, a significant decrease in lordosis was found (p < 0.001)
    - Normal posture vs max posterior tilt – pelvic tilt decreased 8.7\textdegree, lordosis decreased 9.0\textdegree.

Pelvic Tilt and Lordosis\textsuperscript{9}

- Thus...
  - Voluntary assumption of pelvic tilt can significantly alter lumbar lordosis.
  - However, maximal pelvic tilt does not necessarily produce maximal changes in lordosis.
    - Lordosis also influenced by position of lower extremities and thoracic spine.

Pelvic Tilt and Lordosis\textsuperscript{6}

- Day, Smidt, Lehman found similar relationship between pelvic tilt and lordosis.
  - Posterior tilt decreased absolute depth of lumbar curve
    - Significant difference (p < 0.05) compared to neutral and anterior tilt.
  - Anterior tilt increased the absolute depth of lumbar curve
    - Significant difference (p < 0.05) compared to neutral and posterior tilt.
Purpose/Objective

- To quantify changes between normal standing and the five foot positions of ballet, in the pelvis, lumbar spine, and lower extremities

Hypothesis

- We hypothesized that pelvic tilt and lumbar lordosis would increase in 1st and 5th positions compared to normal standing
- We also hypothesized that hip external rotation would increase in all five positions compared to normal standing

Subjects

- Experienced female ballerinas
  - Average 9.8 years of dance experience
  - 14-18 year olds
  - Sample of convenience from local dance companies
  - 14 subjects
- Exclusion criteria
  - Diagnosis of back pain or surgery
  - Current lower extremity injury

Methods and Procedures

- IRB approved and informed consent obtained
- Analysis of 1st - 5th positions vs. quiet standing
  - One trial of each quiet standing, 1st, and 2nd positions
  - One Right and Left trial of 3rd – 5th positions
- Subjects given verbal instruction to assume each position
  - “Assume your normal foot position with the appropriate arm position”

Vicon System

- 3-D motion analysis
- Used reflective targets affixed to skin
- Used 6 infrared cameras at 50 Hz
  - Detect positions of targets
  - Displayed as 3-D image on computer

Methods and Procedures

- 13 marker placements
  - L1
  - S2
  - Bilateral ASIS
  - Joint line of Knees
  - Base and Head of 2nd Metatarsals
- One investigator performed all marker placements to ensure reliability
Marker Placement

Results

- SPSS analytical software
- Repeated Measures ANOVA
- Pearson’s Correlation
- p<0.05 defined as statistically significant

Table: Foot Position vs Normal Stance

<table>
<thead>
<tr>
<th>Foot Position</th>
<th>Difference from normal stance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st position</td>
<td>P=.10</td>
</tr>
<tr>
<td>2nd position</td>
<td>P=.31</td>
</tr>
<tr>
<td>3rd position (C)</td>
<td>P&lt;.01</td>
</tr>
<tr>
<td>3rd position (L)</td>
<td>P&lt;.01</td>
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<tr>
<td>3rd position (R)</td>
<td>P&lt;.01</td>
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<tr>
<td>4th position (C)</td>
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</tr>
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</tr>
</tbody>
</table>

Discussion: Pelvic Tilt

- Significant increase in anterior pelvic tilt found in 3rd-5th positions.
  - Suggest these positions may force pelvis into more anterior tilt because of the asymmetry of pelvis.
- Differed from hypothesis:
  - No significant increase in 1st position as proposed.
  - However, significant increase in 5th position as proposed.
  - Also noted significant increase in 3rd and 4th, not proposed.

Pelvic tilt

- Significant difference in pelvic tilt when compared to non-dancers.
  - Mean pelvic tilt in normal standing in this study = 22.5°.
  - Compared to average found by Levine and Whittle in non-ballet dancers = 11.3°.
  - Possible explanations:
    - Increased to attain ballet positions.
    - Tight low back.
    - Weak abdominals.
    - Tight hip flexors.
    - Long hamstrings.

Results: Lordosis

<table>
<thead>
<tr>
<th>Foot positions</th>
<th>Difference from normal standing</th>
</tr>
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<tbody>
<tr>
<td>1st position</td>
<td>P=.46</td>
</tr>
<tr>
<td>2nd position</td>
<td>P=.01</td>
</tr>
<tr>
<td>3rd position (C)</td>
<td>P=.11</td>
</tr>
<tr>
<td>3rd position (L)</td>
<td>P=.11</td>
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<tr>
<td>3rd position (R)</td>
<td>P=.14</td>
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<tr>
<td>4th position (C)</td>
<td>P=.28</td>
</tr>
<tr>
<td>4th position (L)</td>
<td>P=.23</td>
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<tr>
<td>4th position (R)</td>
<td>P=.33</td>
</tr>
<tr>
<td>5th position (C)</td>
<td>P=.29</td>
</tr>
<tr>
<td>5th position (L)</td>
<td>P=.27</td>
</tr>
<tr>
<td>5th position (R)</td>
<td>P=.33</td>
</tr>
</tbody>
</table>
Discussion: Lordosis
- No significant increase in lumbar lordosis seen except in 2nd position
  - Not in agreement with hypothesis
  - Significance in 2nd possibly associated with arm position
- Trend found when comparing 3rd-5th position trials
  - Suggests influence of leg dominance

Results: Pelvic tilt and Lordosis
- Weak to moderate correlation between pelvic tilt and lordosis across all positions
  - \( R = -0.59 \) \( p < 0.015 \)
  - Possibly due to:
    - Not at end range of motion of the spine and pelvis
    - Use of different strategies to compensate for lack of external rotation (other than lordosis and tilt)

Discussion: Lordosis and Tilt
- Symmetrical vs. Asymmetrical lower extremity posturing
  - Significant increase in lordosis seen in symmetrical posturing, i.e. 2nd position
  - Significant increase in pelvic tilt seen more with asymmetrical posturing, i.e. 3rd-5th positions

Results: Hip External Rotation
<table>
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<th>(L) ER from normal</th>
<th>(R) ER from normal</th>
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</tr>
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<td>( P &lt; .001 )</td>
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<tr>
<td>3rd position (R)</td>
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<tr>
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Discussion: Hip External Rotation
- Significant change in bilateral hip external rotation in all positions vs. normal standing
  - \( p < 0.001 \)
  - Consistent with original hypothesis

Conclusions
- In comparing ballet foot positions to normal stance:
  - Significant increase in pelvic tilt in 3rd-5th positions
  - As proposed, there is a significant increase in hip external rotation
- Additionally,
  - Weak correlation between pelvic tilt and lordosis across all positions
  - Trend found when comparing 3rd-5th position trials
  - Suggests influence of leg dominance
Limitations

- Small sample size (n = 14)
- Uncontrolled extraneous variables
  - Consistency in foot positions
  - Influence of arm positions
- One time assessment

Suggestions for Future Projects

- Standardize foot placements
- Larger and more diverse sample
- Investigate influence of arm positions
- Repeated trials
- Measure hip external rotation with goniometric measurement for comparison
- Measurement of entire range of pelvic tilt available vs. appropriately matched controlled subjects

References