

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

Christy Solly  
Teia Squires  
Rosemarie Walsh



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- Dr. David Levine – study design and statistical analysis
- Dr. Michael Whittle – data collection
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## Foot Positions<sup>1,2</sup>

### ○ 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



## Foot Positions<sup>1,2</sup>

### ○ Second Position

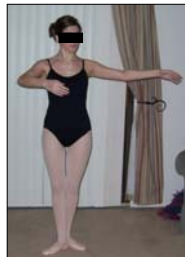
- from first position, slide feet away from each other
- feet are still turned out (close to 180°)
- there is about a foot-length (the length of your foot) in between the heels
- both arms abducted to about shoulder height, with slight bend in elbow



## Foot Positions<sup>1,2</sup>

### ○ 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



## Foot Positions<sup>1,2</sup>

### ○ 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<sup>1,2</sup>

### ○ 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<sup>3-6</sup>

### ○ **Turn-out** is defined as external rotation of the lower extremities<sup>3</sup>

- Achieved primarily at the hips to allow an ideal foot position of 180°
- 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<sup>3,4,7,8</sup>

### ○ 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<sup>9</sup>

### ○ 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°, lordosis increased 10.8°
- With posterior pelvic tilt, found significant decrease in lordosis ( $p < 0.001$ )
  - Normal posture vs max posterior tilt → pelvic tilt decreased 8.7° in, lordosis decreased 9.0°

## Pelvic Tilt and Lordosis<sup>9</sup>

### ○ 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<sup>6</sup>

### ○ Day, Smidt, Lehman found similar relationship between pelvic tilt and lordosis

- Posterior tilt decreased absolute depth of lumbar curve
  - Significant difference ( $p < .05$ ) compared to neutral and anterior tilt
- Anterior tilt increased the absolute depth of lumbar curve
  - Significant difference ( $p < .05$ ) compared to neutral and posterior tilt

## Purpose/Objective

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

## Hypothesis

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

## Subjects

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- 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

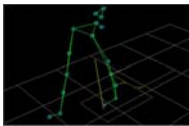
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- IRB approved and informed consent obtained
- Analysis of 1<sup>st</sup> - 5<sup>th</sup> positions vs. quiet standing
  - One trial of each quiet standing, 1<sup>st</sup>, and 2<sup>nd</sup> positions
  - One Right and Left trial of 3<sup>rd</sup>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

## Vicon System

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- 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

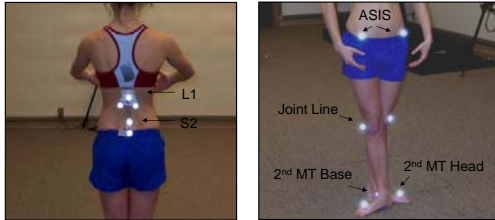


## Methods and Procedures

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- 13 marker placements
  - L1
  - S2
  - Bilateral ASIS
  - Joint line of Knees
  - Base and Head of 2<sup>nd</sup> 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 significance

## Results: Pelvic tilt

Foot Position	Difference from normal stance
C: Combined	
1 <sup>st</sup> position	$P = .10$
2 <sup>nd</sup> position	$P = .31$
3 <sup>rd</sup> position (C)	$P < .01$
3 <sup>rd</sup> position (L)	$P < .01$
3 <sup>rd</sup> position (R)	$P < .01$
4 <sup>th</sup> position (C)	$P < .01$
4 <sup>th</sup> position (L)	$P < .01$
4 <sup>th</sup> position (R)	$P < .01$
5 <sup>th</sup> position (C)	$P < .01$
5 <sup>th</sup> position (L)	$P < .01$
5 <sup>th</sup> position (R)	$P < .01$

## Discussion: Pelvic Tilt

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

## Pelvic tilt

- Significant difference in pelvic tilt when compared to non-dancers
  - Mean pelvic tilt in normal standing in this study =  $22.5^\circ$
  - Compared to average found by Levine and Whittle<sup>9</sup> in non-ballet dancers =  $11.3^\circ$
  - Possible explanations:
    - \* Increased to attain ballet positions\*
    - Tight low back
    - Weak abdominals
    - Tight hip flexors
    - Long hamstrings

## Results: Lordosis

Foot positions	Difference from normal standing
1 <sup>st</sup> position	$P = .46$
2 <sup>nd</sup> position	$P < .01$
3 <sup>rd</sup> position (C)	$P = .11$
3 <sup>rd</sup> position (L)	$P = .11$
3 <sup>rd</sup> position (R)	$P = .14$
4 <sup>th</sup> position (C)	$P = .28$
4 <sup>th</sup> position (L)	$P = .23$
4 <sup>th</sup> position (R)	$P = .33$
5 <sup>th</sup> position (C)	$P = .29$
5 <sup>th</sup> position (L)	$P = .27$
5 <sup>th</sup> position (R)	$P = .33$

## Discussion: Lordosis

- No significant increase in lumbar lordosis seen except in 2<sup>nd</sup> position
  - Not in agreement with hypothesis
  - Significance in 2<sup>nd</sup> possibly associated with arm position
- Trend found when comparing 3<sup>rd</sup>-5<sup>th</sup> 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. 2<sup>nd</sup> position
  - Significant increase in pelvic tilt seen more with asymmetrical posturing, i.e. 3<sup>rd</sup>-5<sup>th</sup> positions



## Results: Hip External Rotation

Foot position	(L) ER from normal	(R) ER from normal
1 <sup>st</sup> position	$P < .001$	$P < .001$
2 <sup>nd</sup> position	$P < .001$	$P < .001$
3 <sup>rd</sup> position (C)	$P < .001$	$P < .001$
3 <sup>rd</sup> position (L)	$P < .001$	$P < .001$
3 <sup>rd</sup> position (R)	$P < .001$	$P < .001$
4 <sup>th</sup> position (C)	$P < .001$	$P < .001$
4 <sup>th</sup> position (L)	$P < .001$	$P < .001$
4 <sup>th</sup> position (R)	$P < .001$	$P < .001$
5 <sup>th</sup> position (C)	$P < .001$	$P < .001$
5 <sup>th</sup> position (L)	$P < .001$	$P < .001$
5 <sup>th</sup> position (R)	$P < .001$	$P < .001$

## 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 3<sup>rd</sup>-5<sup>th</sup> positions
  - Significant increase in lordosis only in 2<sup>nd</sup> position
  - 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 3<sup>rd</sup>-5<sup>th</sup> position trials
    - Suggests influence of leg dominance

## Limitations

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

## Suggestions for Future Projects

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- 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

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