Most forms of dance use turnout. It has been widely described in the literature and yet it is frequently misunderstood. Before 2008 there was no research that systematically sought to scientifically measure the whole leg turnout value by summing all the components of turnout from the hip to the foot. Many people believed that turnout was based on how much external rotation there was at the hip joint, and that contributions from the rest of the leg were relatively minor. The contribution of tibial torsion (see detailed explanation below) was not always included in the discussion. Also missing from these early discussions were variations in the degree of tibial torsion, both between various individuals and between the right and left leg of the same person. How much turnout a dancer had passively and actively was also omitted. (Passive motion is produced by an external force, while active motion is produced by the muscles. See detailed explanation below.) Without a clear understanding of how turnout is achieved, and the role that each part of the leg plays in achieving turnout, it is difficult to teach turnout to dancers and treat turnout injuries in dancers. It was widely believed that poor use of turnout could cause injury and impair training, yet there was no systematic method to measure it. Dancers had no way of knowing if they were turning out too much or not enough; consequently, they guessed where to place their feet. This approach was, at best, unreliable. Dancers and their teachers needed to be confident that they were using the most efficient training method in order to achieve the correct use of turnout. It was imperative that a scientific method for measuring turnout be developed. Our research team sought to do just that. We started by expanding on valid existing systems, adapting some to dance, while devising others, and making suggestions for functional application in the dance studio. The purpose of our research was to better understand turnout for all practitioners: the dancers, the teachers, the somatics practitioners, and the health care providers. We wanted to use science to enhance art. This article will explain the components of turnout from the hip and femur, knee, tibia and foot and the application to dance training.

Understanding the Components of Turnout One Bone or Joint at a Time

Twenty eight dancer’s legs were measured for turnout. External rotation (turnout) at the hip, tibial torsion, and three different measures of whole leg turnout were investigated.

The Hip

The hip is comprised of two bones: the top of the thigh bone, known as the head of the femur, and the socket in the pelvis, known as the acetabulum. The spherical femoral head rotates in the socket. External rotation occurs when the femoral head rotates outward, and internal rotation occurs when the femoral head rotates inward. We used standard and widely accepted orthopedic measurement techniques to measure hip rotation. We found that the amount of external hip rotation in dancers was similar to that found in other studies. We found that there was a slight variation in the range of rotation between a dancer’s right and left hips. Right hip external rotation ranged between 34° to 58°, while left hip external rotation was between 36° to 58° (Table 1).

It was clear that many dancers stand with far more turnout than 58° of turnout per leg and have long careers in dance. Our study sought to ask and answer these questions: Where does the rest of the turnout comes from? Is it a compensation or is it due to the bone and joint structure of the leg?
The Tibia

The tibia (shin bone) in all people (dancers and non-dancers) can twist along the long shaft of the bone such that the top of the tibia and the bottom of the tibia will not face exactly in the same direction.\(^1,6\) This is called tibial torsion. When the tibia rotates on the femur (screwing the knee) this is called tibiofemoral rotation.\(^6\) That is different than twisting of the tibial bone on its long axis. There are two types of tibial torsion: external, when the tibia twists outward and internal, when the tibia twists inward.\(^1,6\) We used magnetic resonance imaging (MRI) to measure tibial torsion in dancers\(^1\) (Fig. 1). These are the only existing and published measurements by MRI of tibial torsion in dancers to date.

All of the dancers demonstrated external tibial torsion. MRI revealed substantial differences in tibial torsion between dancers and even between legs in the same dancer.\(^1,6,7\) External tibial torsion amongst all dancers ranged from 16° to 60° with right to left differences in individual dancers of up to 17° (Table 2).\(^1\) Only one dancer had the same amount of tibial torsion on the right and left sides.\(^1\) Everyone else had differences in tibial torsion when the right leg was compared to the left leg. (We will talk about asymmetric turnout later in this article.)

No dancer had internal tibial torsion in this study, though that happens as well. External tibial torsion adds degrees to whole leg turnout because the foot will be directed outward and internal tibial torsion will subtract degrees because the foot will be directed inward.\(^1,6,7\) The average external tibial torsion was 36° on the right and 34° on the left.\(^1\) Although these averages are provided, those who train dancers are encouraged to work with each dancer’s specific structure. That’s why this paper will discuss individualized training approaches.

Understanding Whole Leg Turnout

The sum of hip rotation and tibial torsion is close to the total whole leg turnout value.\(^1\) A straight knee will not contribute degrees to turnout because it is locked—known as screwed home.\(^1,2,6\) The foot will contribute degrees depending on how much the dancer is rolling in—known as pronation. In pronation, the arch drops down and the toes are forced outward. Some pronation is normal because it helps with shock absorption. A dancer may excessively pronate to make the foot and leg appear more turned out. This is a common method of incorrectly increasing turnout. We attempted to control over pronation (rolling in too much) for this study.

Table 1 Hip External Rotation

<table>
<thead>
<tr>
<th>Minimum (least amount of any dancer)</th>
<th>Maximum (most amount of any dancer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right hip turnout (external rotation)</td>
<td>34°</td>
</tr>
<tr>
<td>Left hip turnout (external rotation)</td>
<td>36°</td>
</tr>
</tbody>
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Image on the left is top of the tibia with the knee cap in front. It is twisted 4° from horizontal.

Image on the right is the bottom of the same tibia with the Achilles tendon in back. It is twisted 36° from horizontal.

The foot will be attached at the bottom opposite the Achilles tendon. Notice that that the foot will be facing a different direction than the knee cap. This tibia demonstrates 32° of external tibial torsion.

Figure 1 MRI of dancer’s leg with 32° of external tibial torsion.
The research team measured turnout in first position using three different approaches:
- Passive turnout
- Active turnout
- Turnout on rotational disks

**Total Passive Turnout (TPT)**
Passive motion is when the movement is produced by someone else and the participant is not helping.\(^2\)
In the case of whole leg turnout, passive turnout would be measured by a trained health care practitioner rotating the entire leg and measuring it to get a number in degrees (Fig. 2). That number will include external rotation at the hip, tibial torsion and the contributions from the foot. This is the body’s true turnout.\(^1,2\) A straight and locked knee will not contribute. External tibial torsion will add degrees to turnout and internal tibial torsion will subtract degrees from turnout. The foot will contribute up to 15°, depending on how much it is pronating.\(^1,6\)

We found whole leg turnout (hip rotation summed with tibial torsion) ranged between 69° to 100° on the right and 70° to 99° on the left (Table 3). That does not include the foot which can add an additional 5° to 15°.\(^1\) Therefore the concept that no dancer has 90° of turnout is false. Some dancers have less and some dancers have more than 90° of turnout. Dancers can have right and left leg turnout that is symmetric or asymmetric. This is why it is important for each dancer and their teacher to individualize training.

**Total Active Turnout (TAT)**
Active motion is produced by the muscles of the person doing the moving (Fig. 3).\(^2\) Total active turnout was measured after asking the dancers to stand as they normally would in dance class. Because muscles are under voluntary control, we found some dancers over turnout and some under turnout. In other words, where a dancer places their feet on the floor is a choice. Most dancers (75%) were over turned out by 8° to 32°.\(^1\) It is worth noting that active turnout can vary each time it is measured, as it can be affected by fatigue or effort.

**Functional Application**
Dancers with a passive turnout measurement that is greater than their actual turnout may need to improve muscle synergies.
Dancers with a passive turnout measurement that is less than how they stand actively are turning out more than their anatomy allows.\(^6\)

**Turnout on Rotational Disks**
Turnout was measured by having the dancers stand in first position on rotational disks (Fig. 4). The testers cued the dancers to ensure correct placement. All the dancers had less turnout on the disks than they had when measured passively (TPT). The average was 27° less turnout per leg on rotational disks.\(^1,6,7\) This relationship has been found to be true by other researchers.\(^8,9\) Disks are not necessarily a true measure of strength but they can be a good indicator.\(^6\)

**Functional Application**
Dancers who have a passive turnout (TPT) that is greater than their turnout on the disks may need to increase strength or improve muscle synergies.

Turnout on the disks will not be greater than passive
turnout unless the dancers are compensating. Common compensations are forcing turnout with excessive pronation of the foot and tipping the pelvis forward in anterior tilt to decrease tension on the Y ligament of Bigelow. The Y ligament is the strongest ligament in the body. It is intertwined with the front of the hip’s joint capsule. It restricts hip extension and lateral rotation. The more you turnout or extend the hip the tighter the Y ligament gets. The reason we commonly see anterior pelvic tilt in dance class is because this flexes the hip, which decreases the tension on the Y ligament, allowing the leg to turnout a little bit more. This compensatory strategy alters muscle function, increases spinal hyper extension, and places additional stress on the medial structures of the knee, leg and foot.

**Lessons From the Research: A Summary**

By studying turnout measurement we have learned:

1. Turnout in degrees is the sum of hip rotation, tibial torsion, and the contribution from the foot.
2. Passive turnout is the body’s true turnout when all the bones and joints contributing to turnout are measured.
3. Active turnout varies, as it depends on where the dancer chooses to place the feet on the floor.
4. Foot placement does not demonstrate how much passive turnout a dancer has.
5. When a dancer does not know exactly how much turnout they have in degrees, active foot placement has to be a choice and a best guess.
6. Tibial torsion can play a large role in turnout.
7. Excessive external tibial torsion can affect the alignment of the knee over second toe (Fig. 5). A tibia that has 25° of external torsion will have a foot facing in a different direction than a tibia with 50° of external torsion.
8. Weakness in the turnout muscles is common. It can affect the alignment of knee over second toe during plié. When dancers and teachers understand that this knee-toe alignment is affected by tibial shape and/or muscle strength, training efficacy can be markedly improved.
9. Tibial torsion affects foot placement in parallel position. In fact, it may be that parallel position, for those with excessive external tibial torsion, is even more difficult than turned out positions, because the hips will have to be relatively turned in to have toes that face forward (Fig. 6).
10. The hip and tibial bony structure is fixed and cannot be changed. For this reason, dancers who have asymmetric turnout because of differences in hip rotation or tibial torsion should use the less turned out leg as a guide for best practice. Note that there are other causes of asymmetry, such as differences in strength (Fig. 7b).

**Conclusion**

Understanding the bony and muscular contributions to turnout should improve the efficiency of dancer training. Furthermore, individualized training protocols should become more clear as dancers apply anatomic knowledge to their own bodies, such as where to place their feet on the floor for optimum and safe turnout.

There were some limitations to this study: a small sample size (28 legs); a standardized warm up was not utilized; and first position with the knees extended was used as a baseline. Expanding analysis to include other positions will add more understanding of this area of research.

**References**

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