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The IADMS Bulletin for Dancers and Teachers

Volume 7, Number 1, 2017

Introduction

Articles

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Letter from the Chair, IADMS Dance Educators' Committee

Dear Colleagues,

As the new Chair of the newly-named IADMS Dance Educators' Committee, I welcome you to the latest edition of the *Bulletin for Dancers and Teachers*; this edition focuses on utilizing and maximizing turnout amongst our dancers. I do hope you will enjoy it and find much to take away into your practice.

I have the pleasure of inheriting this vibrant and hard-working committee from my predecessor, Margaret Wilson PhD – huge thanks to her for her inspiring leadership over the past years. I am indebted to her for all her efforts and for smoothing the transition for me to take on this role. Our committee has representatives from all over the world, committed to disseminating research and practice in dance medicine and science in many ways, from the more formal publications such as this *Bulletin for Dancers and Teachers* and the series of *Resource Papers,* to reaching out at regional meetings and professional development events all over the world and through our Blog posts on the IADMS website. We very much value our interactions with dance artists and teachers as a way of communicating about the work that IADMS undertakes, so please do take a look at the website by following the link, like us on Facebook and stay in touch directly via email education@iadms.org

We have had a range of exciting events over the last year and have met many of you at them. Regional Meetings have happened in Houston, USA, Ipswich, UK and Melbourne, Australia in May and June 2017. These have been widely documented on the IADMS Facebook page and blog so, if you missed any of these events, do catch up with them there. We are already planning events for 2018, including two more Regional Meetings, so keep an eye on social media for those as they are announced. We look forward to the opportunity to meet you at one of these events.

And, lastly, we have some new resource papers published in the last few months – do take a look if you haven't already. Ginny Wilmerding and Donna Krasnow have written a resource paper based on a presentation from the IADMS *A Day for Teachers* in Seattle in 2013 entitled, Dance pedagogy: Myth versus reality. We are also proud to announce the 2016 Nutrition Resource Paper. This document replaces the widely circulated *Nutrition Fact Sheet*, written by Priscilla Clarkson, PhD, in 2003, updating and addressing information which was not available in the first publication. Brenton Surgenor and Andrea Kozai have also published a new paper focusing on warm up this year. This Resource Paper and planned future fact sheets derived from this paper, are aimed at dancers and dance students, as well as dance educators all around the world. The information is based on the most up-to-date evidence-based sports and dance research that are currently available.

Lots of resources then to whet the appetite as we move into a busy year ahead. I look forward to connecting with you in the future.

All best wishes,
Elsa Urmston B.A., M.Sc., PGCap., A.F.H.E.A.
Chair, IADMS Dance Educators' Committee

Letter from the Editor

Dear Dancers and Teachers,

The *IADMS Bulletin for Dancers and Teachers* is pleased to welcome Janine Bryant and Edel Quin to the editorial team. Their wisdom and unique perspectives will help guide the Bulletin forward. Once again we wish to thank Ken Endelman and Balanced Body for their ongoing support.

The *A Day for Teachers* program at the 2017 IADMS Conference was successful, inspirational, and informative. Clair Guss-West explored interdisciplinary approaches to working with dancers. Jane Andrewartha proposed an holistic approach to teaching dance which helps very young children improve their understanding of the mind-body connection. Siobhan Mitchell presented her research on the early maturing dancer. Marita Cardinal reported on the developments of dancer wellness programs in US colleges and universities. There were two exciting panel discussions. *Creating a Culture of Wellness in University Training Programs* was created by Veoletta Dyer, Sarah Wilcoxon, Loren Davidson,Tom Welsh, Ariel Trzaskos, Gabriel Williams and Gayanne Grossman. Maggie Morris, Sonia Rafferty, and Emma Redding discussed how they became advocates for healthy dancing.

This issue of the Bulletin takes a comprehensive look at dancer's turnout. We are grateful to our authors for taking the time to share their expertise. Gayanne Grossman's paper, *Turnout in Dancers: A Comprehensive Overview of Active and Passive Turnout,* describes the anatomy of turnout from the hip to the foot and has functional suggestions for application in the studio. Danielle Pata, Tom Welsh, Veoletta Range, and Jon Bailey's paper, *Improving Dancer Turnout*, discusses exercises to improve turnout and the impressions of dancers and teachers before and after training. Astrid J. Sherman, Erika Mayall, and Susan L. Tasker's paper is entitled *Can a Prescribed Turnout Conditioning Program Reduce the Differential Between Passive and Active Turnout in Pre-Professional Dancers?* These authors reviewed the anatomy of turnout and tested a directed training program to see if it could improve active turnout. We hope these articles will help you in the studio.

During the *IADMS A Day for Teachers* 2017 program, we asked the audience to suggest topics or themes for future Bulletin issues. Psychology and nutrition were recommended as possible topics of interest. The Bulletin team welcomes your ideas! Feel free to drop us a line at Bulletin@IADMS.org.

Sincerely,

Gayanne Grossman P.T., Ed.M., B.F.A., F.I.A.D.M.S.
Editor-in-Chief

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Turnout in Dancers
A Comprehensive Overview of Active and Passive Turnout

Gayanne Grossman, P.T., Ed.M., B.F.A., F.I.A.D.M.S. Department of Theatre and Dance, Muhlenberg College, Allentown, PA

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.[1] 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.[2] 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.

This article was generated from Grossman G. Waninger K, Voloshin A, Reinus WR, et al. Reliability and validity of goniometric turnout measurements compared with mri and retro-reflective markers. J Dance Med Sci. 2008 Dec;12(4):142-52, and Grossman G. Measuring dancer's active and passive turnout. J Dance Med Sci. 2003 Jun;7(2):49-54.

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.[3] 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.[4] We found that the amount of external hip rotation in dancers was similar to that found in other studies.[5] However, 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°[1] (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?

Table 1 Hip External Rotation

	Minimum (least amount of any dancer)	Maximum (most amount of any dancer)
Right hip turnout (external rotation)	34°	58°
Left hip turnout (external rotation)	36°	58°

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 *individulized 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.

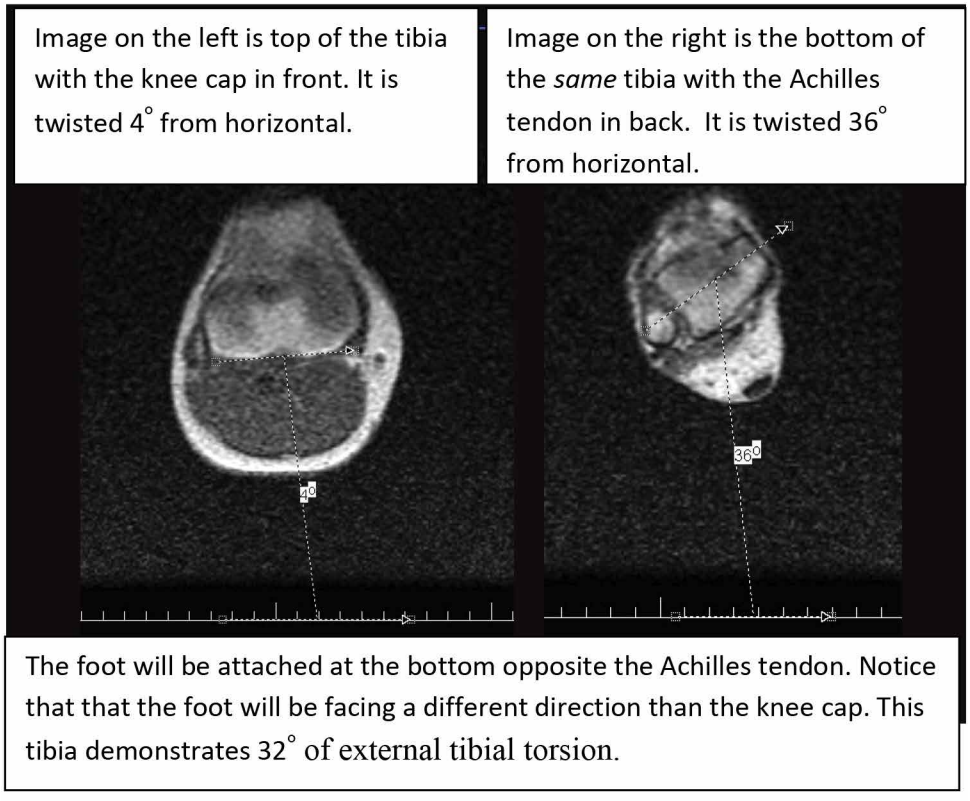

Figure 1 MRI of dancer's leg with 32° of external tibial torsion.

Table 2 Tibial Torsion Values

	Minimum (least amount of any dancer)	Maximum (most amount of any dancer)
Right external tibial torsion	16°	60°
Left external tibial torsion	16°	52°

Table 3 Total Passive Turnout (TPT) Measurements

	Minimum (least amount of any dancer)	Maximum (most amount of any dancer)
Right whole leg turnout without the foot (hip rotation and tibial torsion)	69°	100°
Left whole leg turnout without the foot (hip rotation and tibial torsion)	70°	99°

The research team measured turnout in first position using three difference 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 particpant 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 assymetric. This is why it is important for each dancer and their teacher to individualize training.

Figure 2 Measuring total passive turnout.

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 it 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 measurment that is greater than how they stand actively, may be under using their actual turnout.[6]

Dancers with a passive turnout measurment 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

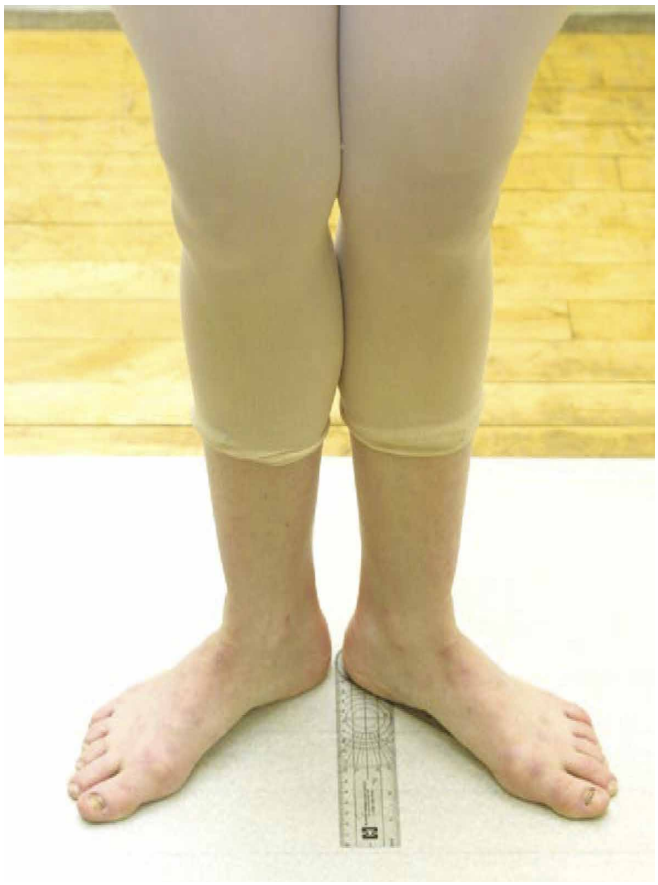

Figure 3 Total active turnout (TAT).

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.[6] 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.

Figure 4 Turnout on rotational disks.

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 efficency can be markedly improved.
9. Tibial torsion effects 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).

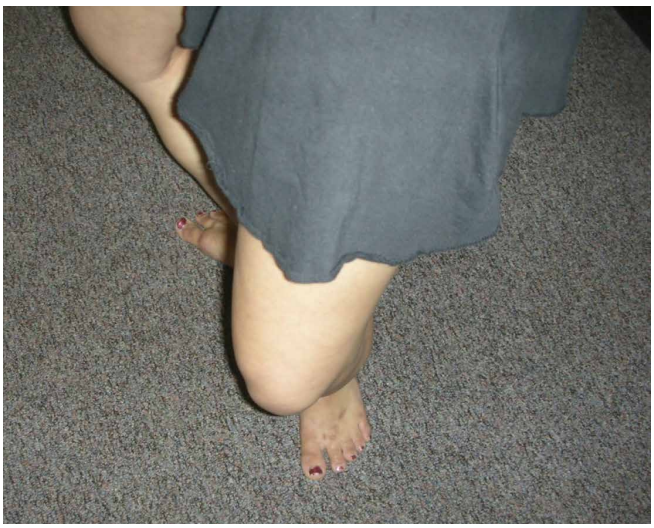

Figure 5 Dancer A with 47° hip external rotation and 45° external tibial torsion in plié. The knee will not go over the second toe unless the toes are pulled inward—and the foot is supinated.

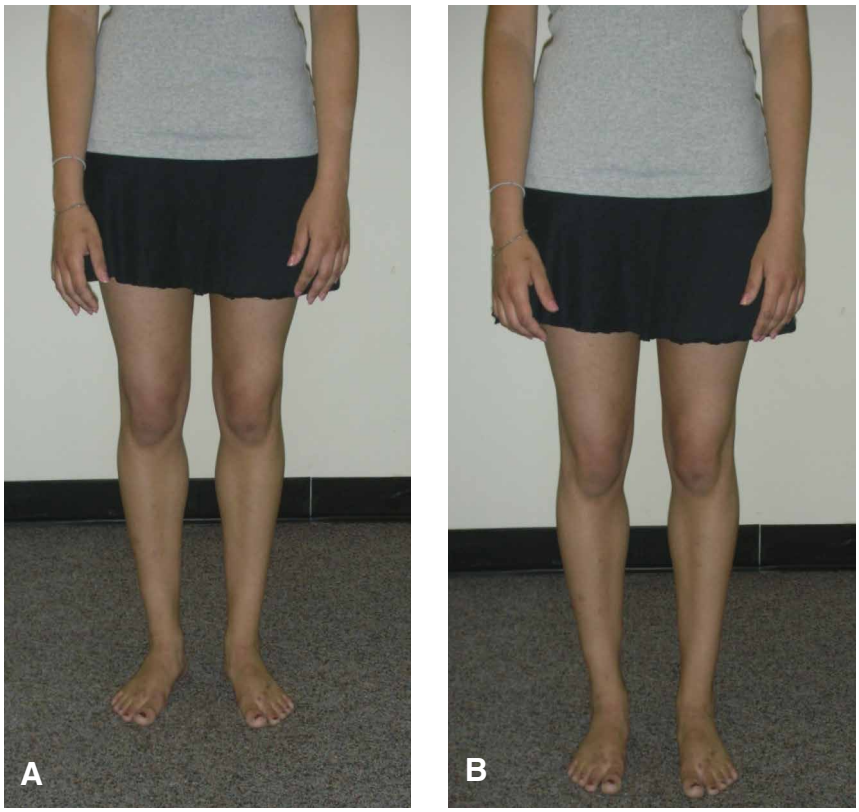

Figure 6 **A**, Dancer A with normal stance: Knee caps are facing forward and the toes are facing outward. The right hip has 46° and the left hip has 47° of external rotation. The right tibia has 48° and the left tibia has 45° of external tibal torsion. **B**, Dancer A standing in a true parallel. Notice the hips are turned in and the knee caps must face inward for the toes to point forward.

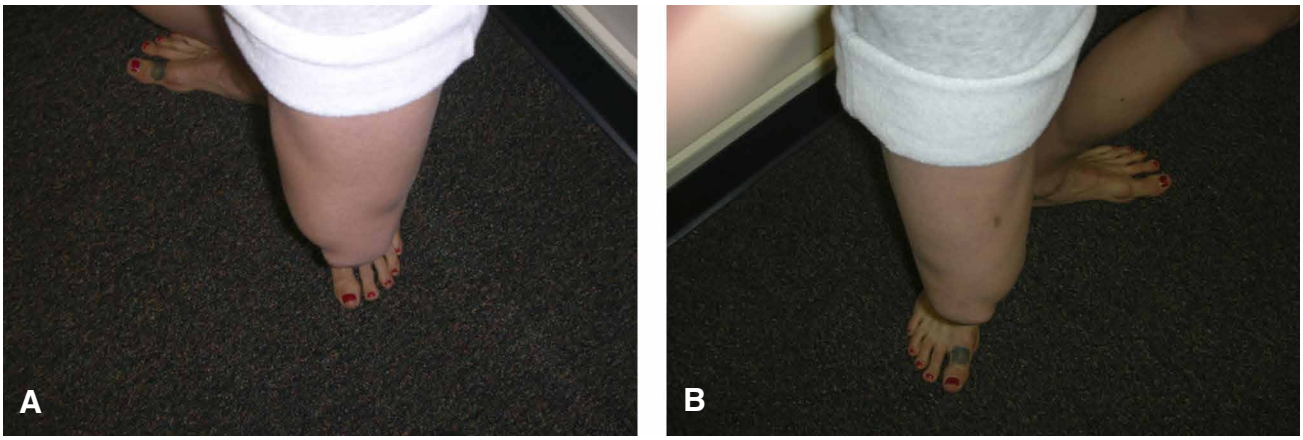

Figure 7 **A**, Dancer B in plié with 53° of hip rotation and 30° of external tibial torsion on the left leg. **B**, Dancer B with 9 more degrees (39°) of external tibial torsion on the right leg. Hip external rotation is the same as the left side. Notice the right knee is not over the second toe as well as the left knee.

10. The hip and tibial bony structure is fixed and cannot be changed. For this reason, dancers who have assymetric 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 assymetry, such a differences in strength (Fig. 7b).

Conclusion

Understanding the bony and muscular contributions to turnout should improve the efficiency of dancer training. Futhermore, 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.

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Improving Dancer Turnout

Danielle Pata, B.F.A., Tom Welsh, Ph.D., Veoletta Range, M.F.A., Jon Bailey, Ph.D.

This article is based on a within-subject experimental analysis[1] of a training approach designed to improve dancers' ability to use and control turnout effectively. In this article, we describe the essential features of the study and emphasize the practical implications for dancers and teachers. A high degree of turnout is desired by many dancers. Turnout is external rotation of the legs from the hip joints causing the entire leg to turn outward, away from the center of the body. Researchers have shown that contributions to turnout are made at several points between the hip and the floor[2] but practitioners seem to agree that emphasis should be on externally rotating the thigh bone (femur) in the hip socket (acetabulum). Well-controlled turnout facilitates: the efficient transfer of weight from one leg to the other; allows for greater extension and control at the hips; satisfies the aesthetic for classical dance forms and may reduce dancers' risk of injury.[3-5] Although using turnout effectively is an essential factor in many dancers' careers, dancers are frequently uncertain how much turnout to use or how to use it properly.[3]

Some authorities say that "perfect" turnout is 180° of external rotation across both legs but it is rare for dancers to be able to manage this degree of turnout without compensations.[6] Regardless of the degree of turnout that a particular dancer's structure can manage, developing the ability to control the degree of turnout that his or her body can accommodate safely is a sought after objective in a dancer's career.[3] Six deep muscles of the hip (piriformis, obturator internus, obturator externus, gemellus inferior, gemellus superior, and quadratus femoris) are well positioned to externally rotate the hip joints without causing compensatory actions in surrounding muscles and joints. It is important for dancers to understand that the force to create turnout should come largely from these muscles working in synergy with other muscles at the hip joints rather than from forcing their feet to the side.[3] Dancers whose anatomy and skillfulness are insufficient to manage the extreme degree of turnout used in some theatrical dance forms (e.g., classical ballet) are prone to compensate and, therefore, put their bodies at unnecessary risk for misaligned postures; bony changes; degenerative joint disorders; decreased lower extremity strength and even emotional problems.[3,4,7]

Several authors have suggested that control of turnout is probably more important than overall range of motion, implying that the emphasis in turnout training might profitably be placed on improving strength instead of or in addition to increasing range of motion.[3,6] Clippinger suggested that turnout training be aimed at building awareness, coordination, and strength in the deep outward rotators.[8] In addition, Daniels suggested that "since many dancers are visual, kinesthetic, and spatial learners, it is important to address multiple learning styles by using anatomical drawings, model skeletons, somatic awareness exercises, palpation, hands-on guidance, imagery, and verbal cues."[5] The purpose of the study we are summarizing was to evaluate the effectiveness of an approach to turnout training designed to satisfy these guidelines.

Method

Six first-year, female university dance majors who, based on prior screening assessments, showed a potential for improving their use of turnout were invited to participate in the study. The participating dancers were typical of first-year dancers in the highly-selective program where we conducted the study. All were likely 18 to 20 years of age with 5 to 15 years of previous dance experience. None of the dancers had current injuries that limited their participation in dance. We studied university dancers because we had ready access to them in a setting where we could conduct the training experiment.

Turnout Training

The dancers met with a trainer (first author) in pairs for 45 minutes immediately before their morning technique

This article was generated from Pata D, Welsh T, Bailey J, Range V. Improving turnout in university dancers. J Dance Med Sci. 2014 Dec;18(4):169-77.

classes for 10 consecutive class days (2.5 weeks; technique classes did not meet on Wednesdays). Each day, the trainer led the dancers through a series of exercises that had been chosen in advance based on recommendations by various experts in the field and based on the apparent effectiveness of the exercises during pilot testing with a different group of dancers a year earlier. During the training sessions, the trainer gave sensation-based cues, presented images of the anatomical structure of the hip, and provided brief lessons on the mechanics of turnout using a teaching skeleton.[3,5,9] The trainer increased resistance and repetitions as the dancers' bodies were ready to accommodate additional challenge. All dancers performed the same exercises but by working in small groups, the trainer was able to offer minor modifications and imagery to match each dancer's individual needs. The within-subject experimental design used for the study can accommodate some individualization by using each dancer as her own experimental control.[1]

The turnout control exercises are described in Table 1 as they were presented to the dancers.

Following training, the dancers were encouraged to continue performing the exercises on their own and asked to keep a record of their work on a written log sheet provided by the trainer.

Assessments

The influence of the training procedures was evaluated with three types of assessments. For the primary assessment, we measured total active turnout, the degree to which dancers were able to externally rotate their legs from the hips down while standing on friction-reducing discs (Fig. 1).[4,13] A member of the research team made sure that the dancers maintained neutral alignment at the pelvis (no anterior or posterior tilt) and the feet and ankles (no pronation or supination) as they performed this action.

For each dancer, total active turnout was assessed once

Table 1 Turnout Control Exercises

Exercise	Description
Awareness	Lie supine with legs in parallel and begin rotating the legs to first position. Feel the rotation happening from the deep rotator muscles, not the legs or the feet. After rotating to first position and back to parallel 3 times, you should feel activation in your deep outward rotator muscles. To increase the sensation, try having someone hold your ankles as you rotate. Repeat the exercise standing and allow the rotation to bring you to rise while placing your hands on your core. Think of the stripes on a candy cane wrapping around the inside of your thighs or the seams of your tights coming together in the back.[5]
Gyro Butterfly/ Clam	Lie supine with soles of the feet touching each other and hands placed on the outside of each knee. Rotate one leg inward until the knee is on top of the other knee, and open it again using your hands while keeping the other knee on the floor as long as you can. Once the other knee can no longer stay on the floor, let it rotate in. Alternate the leg that opens. Repeat opening 16 times at a brisk pace. Repeat the exercise sitting.[9]
Passé Press	Lie on your side with correct alignment. Engage your core and keep the bottom leg turned out as you bring the top leg up to passé and press it into a partner's hand. Squeeze for 3 counts and release for 3 counts.[10] Repeat 4 times on each side. Gradually, increase repetitions to 8 times on each side.[10] Add a développé to second position making sure to keep the rotators working, the core stable, and the hips stacked on top of one another. Try to balance. Then stand up and perform passé position on both sides placing a finger on the greater trochanter, feeling it drop down and under.[5] Find the same sensation you felt on the floor. In center, add a développé to second position, ronds de jambe to rotate on quarter turns, and a rise.
Rotating Side Lunge	Hold on to a barre while in very deep second position plié. Shift most of your weight to one leg while holding your pelvis forward, rotate the gesture leg outward and return without losing turnout of the standing leg or letting the pelvis move away from the barre or sink toward the floor. Repeat 3 times on each side. Increase repetitions to 6 times on each side.[11]
Attitude on Disc	Stand in first position facing the barre on a pair of 9" rotational discs. Maintain maximum turnout on supporting leg while moving the gesturing leg from coupé to attitude derrière 6 times on each side. Make sure the gesturing leg moves straight behind you and the knee is always pressing outward. Then perform 6 relevés with one leg in coupé keeping the full rotation on both legs. On the last relevé, stay on rise and move the gesturing leg from coupé to attitude 6 times. Finally, step away from the barre and perform passé to back attitude and then passé to front attitude on both sides, feeling the same sensation felt on the disks and keeping the hips square.[10]
Stretch	Stretch the hip rotators and extensors by putting the inside leg in front attitude on the barre and twisting the body towards the gesture leg making sure to relax in the hip flexors and to keep the hips square. Hold and repeat as needed. Stretch more of the deep rotators in the seated "pretzel" position[12] making sure to lift up and relax in the crease of the hips. Stretch the hip flexors with the hip flexor lunge.[12] To take this stretch out of the quadriceps and into the hip flexors, scoop in the front of the pelvis. To intensify this stretch, put the back shin against a wall, shifting your weight forward to minimize pressure on the patella.
Cool Down	Lie supine with a pinky or tennis ball under your deep rotator muscles. Relax into the ball as you roll over it for 1 minute.

Figure 1 Total active turnout measurements were made following daily technique classes. Dancers stood on friction-reducing disks to offer their "best turnout" while maintaining neutral alignment at the feet and pelvis. The researcher later used an online graphics tool to measure the angle between the bottoms on the dancers' feet (center of each heel to the base of the second toe). The marks on the dancers' feet do not appear to align with the lines on the steel strips due to a small parallax effect.

per day, four days a week, for nine consecutive weeks. The measurements were made immediately following three hours of morning technique classes. Thirty-five measurements were made for each dancer over the nine weeks the study was being conducted.

In addition to the objective measurement above, we conducted a functional assessment of the dancers' ability to control turnout while performing an adagio phrase. The phrase was designed to challenge the dancers' ability to control turnout. Dancers were videotaped performing the phrase before and after they participated in the turnout training. Before each performance, the primary investigator instructed each dancer to perform the phrase as they would in a ballet class. Three dance teachers who were pursuing graduate degrees in dance performance and choreography (but not teaching the dancers in this study) judged the videotaped performances for each dancer by rating the dancer's ability to control turnout, overall alignment, and artistic expression while performing the phrase. We randomized the order of the recordings so the judges would not know which recording was made before and which was made after training.

The third assessment involved asking the dancers to respond to three questions on a written questionnaire with a rating between 7 (high) and 1 (low):

1. How important is it for dancers to improve their use of turnout?
2. How appropriate were the exercises given in the turnout training sessions?
3. Were the gains achieved with training worth the investment you made?

The dancers were also invited to offer written comments to explain their ratings.

Results and Discussion

Total active turnout on the rotating discs increased gradually throughout the training period for all six dancers. Turnout across both legs increased an average of 14°, with improvements ranging from 9 to 22°. All of the dancers maintained or further improved their turnout after training concluded. Improvements following training were particularly noticeable for dancers whose self-report logs showed that they continued to practice the exercises. Readers interested in more methodological detail may consult the original research report.

The teachers who viewed the recordings of the adagio phrase made before and after training detected improvements in the dancers' ability to control turnout throughout the phrase. The differences were clearest for the teacher who had substantial expertise in the body sciences. In the comment section where we invited the judges to explain their ratings, this particular teacher reported seeing profound changes for each dancer. Her comments describe performance differences that dancers and teachers might expect to be associated, directly and indirectly, with improved turnout control:

- "The initiation of the rotation is coming from the back of the legs."
- "The pelvis looked more stable."
- "Much less hip hiking."
- "The torso looked more lengthened."
- "The chest was more open."
- "I saw a greater level of confidence."

This teacher's ratings identified the "after-training" video as the one showing greater control of turnout for all six dancers, despite not being told which recording for each dancer was made before and after training.

The two teachers who had less experience in the body sciences did not identify similar differences in the dancers' before and after training performances and they were able to identify which performance was recorded before and which was recorded after training in only half of the dancers. This combination of results makes us wonder whether the ability to detect effective control of turnout is a skill that can be developed with specialized training. Future research might be designed to determine whether specialized training might allow teachers to see differences in dancer performance that can enhance training effectiveness.

In the evaluations, we collected from the dancers at the end of the study, all dancers gave high ratings to the importance of improving turnout (all circled the highest rating, 7), the appropriateness of the training procedures (all circled 7), and the value of the gains achieved relative to the time and effort they invested (all circled 6 or 7). Their written comments suggested that they were more aware of their hip outward rotator muscles when taking technique classes, which allowed them to perceive better balance, greater stability and correct alignment. One dancer explained that by becoming more aware of and by strengthening the hip rotator muscles, she noticed that she no longer lifted her hips or tilted her pelvis. Other dancers reported an increase

in core strength and a decreased tendency to pronate at the feet. Dancer 6 wrote: "I am definitely more aware of the muscles I need to use and how to engage them more effectively. However, it will take continued training and mental focus on my part to really reap the greatest benefit."

Implications and Future Research

The results of the study suggest that university dancers can improve their turnout control in a one-teacher-with-two-dancers training environment using a 10-day, 45-minute targeted training program delivered before technique classes. Whether similar benefits can be achieved with dancers in other contexts remains to be demonstrated. Our non-experimental work with younger dancers at summer workshops is encouraging. Assessing whether improvements achieved with this type of training environment will generalize to technique classes is a focus of our current research efforts.

The exercises tested in this study were selected by the first author based on her experience as a dancer, writings by dance training experts, and recommendations by the university dance program's physical therapist. It is possible that other combinations of exercises could be used with similar effects if they are administered in the intensive manner described in this study. Additional research will be needed to answer this question. Future research might also be designed to evaluate whether a longer training duration might produce greater improvements in dancers' ability to use turnout effectively. Finally, assessing the effects of experience in the dance sciences on dance teachers' ability to teach technical skills, such as effective control of turnout, may also be a fruitful topic for future research.

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Can a Prescribed Turnout Conditioning Program Reduce the Differential Between Passive and Active Turnout in Pre-Professional Dancers?

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A detailed scientific study was set-up to explore whether a prescribed *turnout conditioning program* could facilitate an increase in the active use of turnout by pre-professional dancers using their own individual turnout potential. While of some debate, it is reported in the scientific literature that many dancers may use less turnout than that available to them when professionally measured,[1-4] and that significant individual differences also exist across dancers in the amount of "total turnout" they access while dancing.[1,2,5] Key muscle recruitment required for successful stronger turnout was the focus of the *turnout conditioning program* and that exercises were introduced in a manner that, theoretically, should stimulate appropriate activation patterns for proper turnout biomechanics. Dancers make use not only of their innate range of turnout (passive turnout) but also the ability to activate and hold turnout dynamically (active turnout). Consequently, there is a notion that many dancers use less active turnout than that available to them when measured passively.[6-8] This work should be of interest to dance teachers generally but especially those who teach pre-professional ballet and contemporary dance students. Most dance genres demand form and function of active turnout. The study provided some positive evidence that participation in a turnout conditioning program focused on mobilization; strength; flexibility; motor co-ordination and anatomical understanding can produce an increase in the total active turnout and overall performance of dancers' use of turnout.

Components of Turnout and its Development and Training

Turnout is the *sin qua non* of several dance genres, ballet in particular, entrained from the beginner level with the introduction of the codified positions of the feet.[9] Ballet uses the five externally rotated positions as a base for movements in training and choreography. In the world of 21st century classical ballet, "perfect" turnout is now defined as a 180° angle of the feet. The amount of active turnout used by a dancer, which is reflected in the position the dancer assumes, is described as "functional" turnout. Turnout also gives the dancer added aesthetic quality and range for holding a leg in extension (devant, arabesque, or à la seconde), increased freedom of movement and easier transference of weight in travelling sideways, forwards, and backwards. The dynamic alignment of turnout has become the *de facto* cornerstone aesthetic for classical ballet and its training.[6,7] The execution of perfect turnout, however, is an anatomically and biomechanically rare attribute with various studies showing the average functional turnout of dancers to be measured as approximately 133° to 136°.[6,8,10]

However, turnout is comprised of more than just the degrees achieved from positioning of the feet. It includes both hip and non-hip components, with skeletal (bony) and soft tissue (ligamentous and muscular) structures also contributing to the degree of turnout. Skeletal limitations include: (a) the orientation and depth of the hip socket (acetabulum); (b) the shape of neck of the femur bone (femoral neck); (c) the degree of femoral torsion; and (d) the degree of tibial torsion. Looking at these four limitations one by one, we see the following. Firstly, regarding the orientation and depth of the hip socket – the further to the side it sits in the pelvis and the shallower its depth, the greater the passive external rotation.[2,10] A deeper hip socket provides greater stability but may limit external rotation.[2,5] Secondly, long concave (curving inward) femoral necks compared with those that are shorter and less concave permit increased external rotation before bony contact occurs with the rim of the hip socket.[2,5] Thirdly, if the angle of femoral torsion (the angle caused by "twisting" of the head and neck of the femur relative to the shaft of the femur when viewed from above), is less than the average adult measure of 15° to 20° anteversion, this is called retroversion.[2] Retroversion

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results in greater turnout as the knees and feet tend to face outward. Anteversion above 20° is the opposite and often will cause someone to toe-in with knees and feet facing inward. [2] Lastly, the presence of increased tibial torsion (a natural retroversion or external rotation along the shaft of the tibia), can increase natural toe-out of the foot relative to the tibia and enhances turnout range.[4]

Soft tissue limitations to turnout include the joint capsule and associated ligaments (particularly the iliofemoral ligament or "Y-ligament"), which become taut with external rotation. The muscle groups that cross the hip especially the internal rotators and adductors when tight, will restrict range of motion to turnout.[2,3,5,7] The primary muscles used to turnout are the six deep external rotators (piriformis; obturator internus; obturator externus; quadratus femoris; gemellus superior; gemellus inferior) and the gluteus maximus. Other secondary muscles are the sartorius; biceps femoris and posterior fibres of the gluteus medius which function to assist and support external rotation, depending on limb placement (e.g., the sartorius can assist in turnout for low height—not higher than 45°—extension devant and biceps femoris can assist in holding and gaining more turnout out in plié and attitude derrière turnout by its function of resisting internal rotation of the knee).[5,11] In all positions however, it is preferable for dancers to be taught to use the deep external rotators as primary turnout muscles. Inefficient muscle patterns are set up by over-recruiting external rotation muscles that have other primary jobs, for example, many dancers using the gluteus maximus will have a "tucked" pelvis,[12] and the resulting tension limits turnout range. Similarly, tightness and over-recruitment of the sartorius and gluteus medius can cause "hip lifting" (hitching up of the iliac crest), which is not a desired aesthetic in most schools. Detrimental strain can also be placed on the body from the creation of artificial turnout at the knee and ankle instead of being focused mainly from the hip. Another point to remember is that in ballet, the lifted leg needs to also be able to display turnout devant, à la seconde, and derrière, and thus different muscle groups come into play at different times.[12] Finally, overly tight turnout muscles ultimately decrease ability to achieve full range, therefore all muscles that cross the hip should be stretched.

Further to soft tissue contributions to functional turnout, studies indicate two important factors: adequate strength and appropriate activation patterns of key muscles for the optimizing of correct mechanics of turnout.[4,5,12] For example, many dancers' natural turnout may be greater than that which they have the strength to hold and muscles tend to be weakest at their end ranges. This is precisely where many dancers desire to position their turnout.[4] Inefficient muscle activation patterns result from many dancers' inability to isolate or properly use the six deep rotators (the prime movers), which in turn leads to over-recruitment of secondary muscles. Researchers and orthopaedic surgeons suggest that 50% to 70% of the desired 90° turnout from each leg is contributed by the hip, with 10% to 40% coming from the lower extremities.[2,7] When the knee is straightened, the foot and lower leg naturally assume a turned-out position of 15° to 30° in the average person. This primary non-hip component of turnout is tibial torsion, which, for the average dancer, facilitates the turning out of the feet by 15° to 20° more than the knee without creating excessive torsion stresses at the knee.[5,6,7,13,14]

As most dancers are unable to achieve ideal turnout from the hips alone, the use of compensatory strategies is common, including pronating the feet, tilting the pelvis anteriorly (forward) and "screwing the knees" (achieving the desired turnout from below the knee). Compensated turnout has been strongly linked to overuse injuries in dancers.[5,7,11] For example, forcing turnout from the feet is associated with knee injuries: if the foot is forcibly turned out beyond the range available in the hip joint and torsional forces occur that exceed tolerance of the knee joint, often resulting in medial meniscus issues. Screwing the knees involves failure to rotate the femur externally within the hip socket, resulting in the patella facing forwards and the creation of a torque action on the knees. To minimize compensated turnout and associated injuries some orthopaedic surgeons hold the opinion that a minimum of 60° hip external rotation is required by age 15 for a safe career in classical ballet.[7,15] This may be a strong argument, and it does reinforce the concept that 180° turnout might not be possible or "safe" for all ballet students.

The Turnout Conditioning Program

Female pre-professional dancers (13 to 17 years old, training 20 to 25 hours a week) were measured before and after the 7-week program for total passive turnout and active turnout. Passive turnout is defined as turnout movement produced by a tester/measurer without assistance from the dancer and active turnout is defined as turnout movement produced by the dancer through active muscle recruitment. Active turnout was measured in both a static range (measured by the physiotherapist when standing in first position on paper), and a dynamic range (measured by the physiotherapist standing in first position on rotational Balanced Body® discs).

The conditioning program included a selection of exercises from experts in the field of dance conditioning, plus some from both authors' repertoires. These specific exercises can be easily substituted with other equivalent exercises, however this may impact upon the effectiveness of the programme, as determined by this specific research study. The conditioning program comprised the series of exercises listed and described below. Mobilization was always done first, followed by strengthening, then stretching exercises, and culminating in an application exercise. The program developed as the dancers gained more familiarity with it. Not all exercises could be introduced in the first lesson; an attempt was always made to have a balanced representation from all the sections. More repetitions and exercises were added as dancers progressed. Readiness to progress was determined by the program instructor through observation of secure execution;

Figure 1 Correct side-lying posture with supported waist and hip-on-hip placement.

Figure 2 Theraband band resistance exercise in partners.

specifically, a participant progressed when she was observed to be consistently executing an exercise proficiently in terms of placement and alignment. Not every exercise was included in each session. In the actual study, this 45-minute session was delivered for 7 weeks, 3 times per week.

Detailed anatomical explanation was provided when exercises were first taught. As the participants gained familiarity with the exercises, kinesthetic, auditory, visual, and mastery imagery cues were given as reminders and encouragement. For example, to feel the gluteals as "baggy" and the rotation just coming from a deep underlying muscle "nipping" at the bottom of the dance leotard elastic.

1. Warm-up Series[1]: (5min)

Exercises emphasising inward and outward rotation in an easy "movement" format:

a) Standing with "relaxed" knees stepping feet in, in, out, out with alternate feet.

b) Sitting with legs parallel, knees flexed and feet on the floor, drop knees alternately down to "froggy" (soles of feet together, knees flexed, hips externally rotated) and back up (down, down, up, up).

c) Sitting in "froggy", gently bounce the knees in a relaxed motion.

d) Sitting starting as for (b), use pressure from hands to gently push to "froggy" and then close.

2. Strengthening Series: (20min)

For all exercises, it is important to include the use of imagery (kinesthetic, auditory, visual, and mastery imagery cues given as reminders and encouragement) and anatomy together with breathing patterns and abdominal engagement. All exercises emphasise activating the six deep external rotators as *primary turnout* muscles:

a) Sidelying Combination[2,3] (Fig. 1)

Feel the work beneath the top layer of gluteals (deep external rotators); the top gluteals should not be tensed. The gluteus maximus can function as an external rotator, but its main function is hip extension. Focus on rotating lower at the bottom of the buttocks and deeper – more specific and less forceful: think of bringing the greater trochanter back toward the ischium or "sits" bones.[2]

1. Flex knees up to body to about a 60° angle, body lying on right arm in lengthened spine position, left hand balancing the body. Externally rotate left top hip to turnout retiré without upsetting "hip on hip" placement and thus using functional range.

2. Stretch bottom leg and bring top leg to 90° angle to chest and parallel to the floor; repeat the retirés, feeling the greater trochanter of the femur rotate toward the sit bones. Focus on a functional use of turnout.

3. Straighten the top leg with plantar flexion (pointing) of the foot to just above stretched bottom leg and rotate the leg inward and outward in the hip socket.

4. Press top leg to hip extension (dégagé derrière) then slight flexion (dégagé devant), add slight attitude and stretch and rotate inward and outward.

B) Resistance Exercises[4] (Fig. 2)

1. Ball exercise: Dancer lying prone (on stomach) with one leg in retiré. Place a small soft ball under the foot (or

knee) of the retiré leg. With abdominals engaged, lengthen the retiré knee away from centre and try to get both hips on the floor. Those who can get both hips on the floor are to try to lengthen the thigh bone of the retiré leg away and to slightly raise the knee.

2. Theraband resistance: in partners or tying theraband to a barre leg, rotate femur by aiming foot toward retiréposition. To strengthen deep external rotators, keep hips down and abdominals engaged. This exercise offers excellent balance and proprioception training for standing student as well. (The standing student can try "eyes closed" proprioception to challenge balance).

c) Supine (Lying on Back)[1]

Movements are smooth and controlled to fullest range, basic posture must be maintained. Arms can be in a "V" next to body, palms down or first/fifth position, abdominals engaged. Start with legs turnout demi-plié heels together and feet dorsiflexed. Open/abduct legs to a wide second position fully extending knees in line with pelvis, feet plantar flexed (pointed), as the maximum is reached, adduct and close medially rotating and flexing knees, feet remain plantar flexed (close legs to parallel retirés with pointed toes). Vary speed in a 3-count rhythm.

d) Prone (Lying on Stomach) Combination[1]

1. Cross hands under forehead, legs parallel on the floor, feet plantar flexed, abdominals engaged (because the back muscles will be engaged in this exercise, pushing the belly button to the spine will engage the abdominals so that they work synergistically with the back muscles), (Fig. 3). Hyperextend the right leg, lengthening out of the spine, isolate in hip and externally rotate, flex knee to a small attitude, extend to wide second position, rotate in and out return to parallel then down. Use alternate legs (this is a challenge to maintain trunk stability as working unilaterally with one leg at a time drags on the pelvis), then with both legs.

2. With arms abducted to 90° and palms facing the floor position, knees flexed to 90° and feet dorsiflexed, raise legs slightly off the floor keeping knees together (Fig. 4); abduct legs, extending knees to turnout second as wide as possible, inwardly rotate, externally rotate, reverse back to starting position.

3. Stretching Series: All Muscles that Surround or Connect in the Hip Area: (15 minutes)

All muscles that cross the hip should be stretched. As noted earlier, in ballet, the lifted leg is required to present turnout devant, à la seconde and derrière, and thus different groups come into play at different times.[2,3] Overly tight and tense turnout muscles ultimately decrease ability to use the full range of motion:

a) Include a Stretch/Release for Each of the Following:

1. Iliopsoas, hip flexors and quadriceps
2. Hamstrings
3. Iliotibial band
4. Gluteals and deep rotators
5. Adductors

b) Tension release[3]

Using a 2.5-inch plastic or dense rubber ball and lying with the ball under the hip, roll the ball everywhere from sacrum, around sides of pelvis and middle lower buttocks. Stop at areas of "knotty" pain until the muscle relaxes. This

Figure 3 Prone position supporting head on arms with abdominals engaged.

Figure 4 Prone position with arms abducted to 90° and palms facing the floor.

Figure 5 Standing stabilizers in battements fondus.

can be done against a wall as well, or use of a foam roller.

4. Application/Carry Through Exercises: (5 minutes)

Examples of how to utilize some of the imagery and anatomy in **any** ballet type exercise:

a) Standing Stabilizers in Battements Fondus[3] (Fig. 5)

Focusing on the turnout of the supporting leg will keep dancers from injuring knees and ankles and give strength to control a turned-out supporting leg in the centre. Explore the turnout in both the supporting and working leg, feel where the deep external rotators work on the supporting leg and where the accessory turnout muscles (sartorious devant, biceps femoris derrière) can aid these rotators in the working leg.

Rising on the supporting foot can add more control challenge and the use of dorsiflexion in the gesture foot can be added to feel extra rotation.

b) Plié in Second Against Wall Combination[2]

Standing with back against wall, feel back on wall: engage abdominals for correct pelvic placement. Rotate femurs with deep external rotators before starting descent into plié. Engage adductors on ascent to aid deep external rotators in maintaining turnout in stretching the legs. Also, use this with first position demi-plié to feel how turnout of the femur "starts" the plié.

Discussion

Students showed encouraging improvements in the repeat measurements taken after the study compared to the before measures. As a group, participants showed an improvement in their active turnout measured in a static range (standing in first position on paper) and a significant improvement in dynamic range with turnout attained and securely sustained (standing in first position on the rotational discs). These improved measures of active turnout are meaningful given that the dynamic alignment of turnout is the *de facto* cornerstone aesthetic for classical ballet and its training.[6,7] Our findings of improvement on active measures following the training program suggest that the inclusion of additional exercises in dancers' training to facilitate hip mobilization, strengthen muscles and their activation patterns, and gently stretch the hip musculature and associated soft tissues can facilitate improved functional range and control of active turnout. High quality and healthy practice in training and developing functional turnout is important for mastering both the aesthetic and practical execution and control of turnout in dancers aspiring to professional careers in ballet. Emphasis must be on both quantity and quality of turnout.

To be noted, we found no change in the passive turnout measures (the individual dancer's unique and innate range of turnout) following the training program. However, this was expected, given the age-group of our participants. By the time they are 13 years of age, most pre-professional dancers will be working within their maximal zone accrued from the training, strengthening, and stretching of the involved soft tissue during early dance training years. Various studies[14,16] theorize that early training before age 11 years of age may be able to affect change in bony constraints, allowing for a modelling and shaping of femoral torsion. Beyond this age, improvement would result from the stretching of soft tissue constraints. As stated earlier, all participants in the present study were pre-professional dancers who had been dancing from the ages of 5 to 8 years of age. For the most part, it was their range of motion and flexibility that allowed them to progress into pre-professional training. In summary, we suggest our findings indicate that the development of functional turnout in dancers appears to rest on a combination of their innate anatomical capacity

and sound, technically-correct training and the inclusion of additional turnout targeted exercises to facilitate active turnout capacity.

Imagery

Dance teachers in general use imagery (especially metaphorical imagery) more spontaneously in their instruction than coaches of other athletes.[17,18] Imagery is a skill that serves both cognitive and motivational functions,[19] and is endorsed in the sports psychology literature as an important component of training across all levels of participants.[17] In particular, the use of imagery might have contributed to the increase the instructor observed in participants' cognitive understanding and application of turnout in their regular ballet classes following completion of the Turnout Conditioning Program. In each session of the Turnout Conditioning Program, the instructor discussed the muscles involved and used visual, kinesthetic, auditory, and mastery imagery to describe the "look," "feel," "sound," and pictured "usage" of turnout.

Conclusion

In summary, individual anatomical turnout capacity, and sound technically correct training are central to the development of functional turnout in dancers. However, the inclusion of additional exercises in dancers' training programs that (a) facilitate hip mobilization, (b) stretch the hip capsule and associated turnout muscles and (c) strengthen muscles to enhance their activation patterns, may facilitate improved functional range and control of active turnout, and would be beneficial for pre-professional dancers and their teachers. Teachers should note that there was a high degree of variability observed in all measures in the present study and it should serve as reminder that all dancers are highly individual, hence, teachers will do well to allow individual variation in the degree of active turnout each dancer can use in an ambitious, yet safe, and proficient manner. Also, dancers and teachers are encouraged to remember that because joint range of motion is unlikely to improve after age 11 years, the major focus of a turnout conditioning program should be exercises that retain the natural flexibility of the dancer's joints rather than trying to improve it. Then, working from well-maintained natural turnout and flexibility bases, exercises that stimulate strength can be successful in improving perhaps the quantity, but certainly the quality and control, of active turnout available to dancers.

Physical *and* cognitive components are important elements of turnout. By helping dancers to become aware of, think about, and visualize their natural and true passive range of turnout, they can be encouraged to consciously and effortlessly explore and use more of their natural range of turnout. The explicit inclusion of imagery cues in turnout conditioning programs can help cultivate dancers' cognitive insight into the "why" and "how" of biomechanics and the "look" and "feel" of their individual active turnout practice and control. As dancers expand their cognitive understanding of the mechanics and kinesthetic sense of turnout, they may find greater motivation to condition and retain turnout flexibility and strength, and enjoy increased proficiency and confidence in their use and control of turnout.

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