

Physiological Characteristics and Training Strategies of Key Muscles Required for Ballet Turnout

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Abstract. Turnout (i.e., rotating the lower limbs outward from the hips) is a foundational and highly demanding technical movement in classical ballet. Although this action is often associated with aesthetic expression, its completion relies on the deep synergy between skeletal structure, muscle involvement, and neuromuscular control. This article comprehensively analyzes the anatomical and physiological factors that affect turning, focusing on the key differences between passive turning ability and active turning ability, the potential impact of compensatory strategies, and the regulatory role of age and developmental stage on training needs. The research results indicate that in the training of turning movements, prioritizing the strengthening of active muscle participation is more important for preventing injuries compared to simply pursuing flexibility. Based on the relevant insights of sports medicine and dance science, this study further proposes an age-adapted training adaptation conceptual framework, indicating that the turning training strategy should be dynamically adjusted according to the biological development process of dancers. By integrating anatomical knowledge with practical training requirements, this study emphasizes the need for more personalized injury prevention methods in classical ballet teaching in order to improve training effectiveness and ensure the long-term physical health of dancers.

Keywords: Passive turnout, active turnout, injury prevention.

1. Introduction

“Turnout” refers to a movement that is a central technique in ballet. It involves the external rotation of the lower limbs, originating from the hip joint. Turnout enables a greater range of motion and consequently assists in creating aesthetic alignment for movements utilized in ballet. Traditional ballet methods lay its groundwork on the ideal 180 degree turnout, surpassing what is anatomically achievable for most dancers [1]. Such a notion often forces ballet dancers to engage in compensatory movements. Hence, understanding the physiological foundations is crucial in order to minimize long-term damage that poor turnout technique may bring as well as for aligning training goals with each dancer’s unique structural potential.

From an anatomy standpoint, there are numerous skeletal contributions to turnout, including the femoral neck angle, acetabular orientation, and ligament structures [2]. The six deep lateral rotators of the hip are also highlighted by studies, as the muscles control motor alignment in external rotation

[3]. Research has also warned against the potential dangers that compensatory turnout may cause: overuse injuries, chronic pain and musculoskeletal instability [4].

Despite the growing concentration of anatomical research, ballet pedagogy and training approaches remain rooted in prioritizing aesthetic ideals rather than injury-preventive and safe practices, though improvements have been shown. In many ballet training methods, for instance, the Vaganova and Cecchetti, there has been an increase in integration of scientific literature. Nevertheless, systematic training adaptations are rarely formalized. While rehabilitation practices in sports medicine have long employed stage-specific protocols, similar frameworks for dance training are not yet widespread in academic literature or practical application [5].

This paper addresses the need to bridge the gap between anatomical understanding and practical application in ballet training. It presents a comprehensive synthesis of the structural and muscular requirements for effective turnout, explores the risks of compensatory strategies, and examines how developmental changes (especially during adolescence) impact a dancer's turnout potential. The paper draws from interdisciplinary research to suggest that training strategies might be improved by taking into account biological maturity. Although not introduced as a formal model, the paper briefly outlines how a stage-specific approach could guide turnout training at different developmental stages.

2. Muscular and skeletal anatomy of turnout

Turnout, external rotation of the lower limbs, is a foundational principle in all dance styles, especially ballet technique. Anatomically, turnout primarily originates at the hip joint but is influenced by the alignment and flexibility of the knees, ankles, and feet, typically manifested as external rotation of the lower limbs to increase the range of motion (ROM) for abduction [6]. The ideal 180-degree turnout, where the feet form a straight line, is rarely anatomically possible for most dancers without compensation and risk of injury [1].

The hip joint structure focuses more on stability rather than flexibility, supported by deep hip sockets and robust ligaments [7]. The hip joint is made up of the ball and socket, where the ball is the femoral head and the hip socket forms a half sphere. This joint plays the central role as the degree of turnout is limited by skeletal features such as the angle of femoral anteversion, orientation of the acetabulum, and shape of the femoral neck. For instance, a retroverted femur and a laterally facing acetabulum facilitate greater turnout, while an increased anteversion angle may restrict it.

The iliofemoral, also known as Y ligament, is the strongest ligament in the human body, diagonally crossing the front of the hip joint, reinforcing the joint and limiting hip extension and external rotation, making it difficult to achieve complete turnouts in arabesque. The pubofemoral ligament supports the back of the hip capsule and primarily restricts hip abduction, such as lifting the leg to *à la seconde*. Meanwhile, the ischiofemoral ligament limits adduction and internal rotation, which together stabilize the hip joint but also limit certain movements necessary for ballet turnouts [2].

According to Physiopedia, the key muscles responsible for ballet dancers' turnouts include the six deep lateral rotator muscles of the hip joint: *infrapsoas*, *piriformis*, *adductor internus*, *adductor externus*, *levator*, and *quadriceps*. These small, stabilizing muscles are located beneath the *gluteus maximus* and are responsible for fine-tuning the rotation of the femur within the hip socket. Unlike the larger gluteal muscles, which support hip extension, the deep lateral rotators are specifically responsible for external rotation. Other supportive muscles include the *adductors*, *iliopsoas*, *gluteus medius* and *transverse abdominis*, which help maintain pelvic stability and spinal alignment during turnout.

Ballet teachers use these anatomical principles to instruct dancers on how to turnout properly [8]. Dancers are told to engage the gluteal muscles to maintain hip external rotation and slightly supinate the feet so the outer edges press into the floor while the arches lift. Toes should stay relaxed, and the kneecaps should align with the second toes. The hips must remain in a neutral position, with thighs together in first position. Core and back muscles are engaged to support and stabilize the turnout.

3. Key differences in muscle engagement for dancers with passive vs. active turnout

The distinction between passive and active turnout in ballet is an essential aspect of a dancer's training regime. Passive turnout refers to the external rotation of the hip that occurs without conscious muscle engagement. In other words, passive turnout relies primarily on the inherent flexibility of the ligaments and the structural ROM of a dancer's hip joint. On the other hand, active turnout involves the deliberate activation of specific muscles to achieve and maintain the desired rotation [9]. This active engagement is crucial to prevent imbalances and asymmetries, since dancers who rely on passive turnout experience [10]. This is due to the fact that a significant portion of turnout is not often generated at the hip and instead compensated through the distal joints. Thus, dancers who lack adequate engaged hip external rotation frequently compensate by twisting through the knee or forcing turnout at the ankle.

A study found that, on average, 32% of turnout on injury-free female dancers was achieved through knee joint compensation or compensatory turnout (CTO) [4]. Additionally, dancers with higher CTO values are more likely to be injured due to a higher risk for chronic overuse. In particular, Coplan found that an astonishing 90% of college-level ballet dancers with a CTO greater than 25 degrees experience injuries. Meanwhile, dancers with lower CTO values, usually under 26 degrees, reported no injuries [6]. Jenkins and colleagues reported that the odds of sustaining two or more injuries rose by 9% for every 1% increase in CTO, highlighting the cumulative risk associated with compensatory movement strategies. Notably, poor control of CTO has been linked with both low back pain and tendinopathies, particularly through excessive anterior pelvic tilt and instability of the foot and ankle [6].

Foot posture also plays an important role in turnout mechanics and injury risk. A pronated foot, characterized by an unlocked subtalar and midtarsal joint, presents an unstable structure that demands greater functional control from intrinsic foot muscles. Carter and colleagues wrote that this instability of the foot increases tensile forces on tendons, which may predispose dancers to overuse injuries such as posteromedial tibial stress syndrome, plantar fasciitis, and flexor hallucis longus tendinopathy. When paired with excessive CTO of the knee and inadequate hip rotation, compensatory foot mechanics exacerbate musculoskeletal strain, reinforcing the need for strength training in specific muscles to encourage proper active turnout.

4. Age and development factors to turnout

When it comes to ballet, age and the growth stage of the dancer are important factors that influence their turnout. As ballet students go through puberty, progressing from childhood into adolescence, their bodies also go through changes that can impact their turnout capacity, often improving it. For instance, maturation can cause the hip bone to grow and change shape. These physical changes that occur can greatly influence the strength and flexibility of their muscles and joints.

Therefore, training strategies must keep pace with the dancer's growth, ensuring that any improvements in external hip rotation gained through maturation are backed up by appropriate coordination exercises and muscle strengthening. Rather interestingly, musculoskeletal

characteristics and sociodemographic factors can vary between genders, which requires different diagnostic and training approaches to ensure a safe development process for all dancers [11]. In particular, female dancers often struggle to meet the physical and social expectations of ballet, which negatively impacts their psychological well-being [5]. Furthermore, male dancers commonly experience growth spurts later than their female counterparts, which often means their facing sudden changes in limb length and body proportions that can cause previously mastered movements to feel unfamiliar.

As a result, the implementation of personalized training plans that cater to an individual's physical capabilities and stages of development is a promising plan for optimizing performance outcomes. Monitoring tools may be implemented, such as regular physical assessments, growth tracking, and mental health check-ins. Teachers should also be aware of early signs of overtraining, burnout, or biomechanical imbalances. In this way, a more holistic, individualized, and evidence-based approach to training can support both the short-term progress and long-term career of young dancers.

5. Recommended exercises to improve turnout

Targeted strengthening of the external rotators is crucial to facilitate the attainment of the desired degree of turnout. For instance, clamshells are an integral exercise primarily due to their effectiveness in activating the gluteus medius and deep lateral rotators [12]. This exercise trains dancers to use the correct muscle groups rather than compensating with the quadriceps or lower back, a common issue that can lead to passive turnout. When clamshells are performed consistently and with correct form, they can build muscular endurance and improve active external rotation, enabling dancers to apply strength to choreography [5].

Theraband rotations are widely incorporated into dance conditioning because they provide a dynamic method of strengthening the hip's external rotators, muscles that underpin turnout. The variable resistance of the Theraband requires dancers to maintain consistent muscular engagement throughout the entire arc of motion, unlike static exercises that are used for pure strength training. This not only builds strength but also refines neuromuscular coordination, as the muscles must adapt continuously to the band's tension [12]. A further benefit is the improvement of proprioceptive feedback (the body's ability to sense and control joint position), which plays a crucial role in sustaining balance and alignment during turns, extensions, and complex sequences [13].

Meanwhile, turnout planks address hip strength and core stability. This exercise involves maintaining the plank position while externally rotating the hips, demanding simultaneous activation of the deep rotators, abductors, and the isometric stabilizers of the trunk. Training dancers to stabilize in weight-bearing positions, this movement forces them to hold their pelvis steady, which can limit knee or foot compensation [12,14].

This notion is also supported by current rehabilitation research; for example, clinical protocols for dancers recovering from hip-related conditions (such as femoroacetabular impingement) frequently prioritize progressive strengthening of external rotators. Structured overload will lead to sustainable recovery is a principle long recognized in athletic training, something these carefully sequenced programs highlight [5]. As a matter of a fact, when adapted to injury-free dancers, these rehabilitation methods can also function as preventative conditioning through strengthening.

In order to achieve lasting benefits through suggested exercises, consistency and progressive adaptation must remain the priority. These exercises must also challenge a dancer's evolving capacity through maturation by encouraging systematically scaled models. Systematically scaled

programs include gradual increases in resistance, duration, or complexity in the exercises, encouraging steady gains in muscular endurance [1,14].

Another factor to be taken into account is the adaptation of training across developmental stages. Initially, in early childhood (ages 6-11), dancers often display flexibility that exceeds their muscular control. This suggests that the primary focus for dancers at this age should be proprioceptive drills, posture awareness, and basic motor coordination, rather than focusing on heavy resistance. During adolescence (ages 12-15), rapid growth alters limb length and joint mechanics, which can disrupt coordination; this transitional stage is therefore ideal to center on supervised strength training of the external rotators and stabilizers to establish evenly engaged turnout. Generally, by late adolescence and adulthood (16+), dancers are prepared to integrate higher-resistance training into their workout routines, promoting joint health in the long run [5]. Such training methods parallel principles in youth sports medicine, which emphasize aligning the training demands with biological, rather than chronological, development. Applying this model to various ballet training programs could enable teachers and clinicians to design conditioning programs that both safeguard young dancers and provide a structured pathway toward achieving durable, efficient turnout.

6. Conclusion

This paper investigates the various physiological components of ballet turnouts based on anatomical, muscular, and developmental factors that affect dancers' ability to safely achieve active external rotation. The importance of muscular control, in both injury prevention and performance optimization, is emphasized through distinguishing between passive versus active turnout and identifying the risks of compensatory movement at the knees, ankle, and feet. The role of growth and biological development emerged as a critical variable, particularly in adolescent dancers, requiring special consideration in training design. In addition, this paper also introduces that switch training may benefit from adapting to the developmental stage. Drawing inspiration from rehabilitation and athletic training literature, a brief, informal framework was proposed in which training strategies are adjusted according to a dancer's growth phase: foundational alignment and proprioception in childhood; strength and neuromuscular conditioning in early adolescence; and individualized optimization post-puberty. While this approach remains theoretical within the scope of this paper, it offers a promising direction for future research and practical experimentation. Limitations of this study include its reliance on secondary sources rather than primary experimental data and the absence of clinical trials to validate the suggested framework. Future research could evaluate the effectiveness of stage-specific turnout training in reducing injuries and improving technical outcomes. Longitudinal studies tracking dancers from childhood through professional training would be especially valuable in verifying how biological development interacts with training interventions. Experimental trials comparing traditional training methods with stage-specific programs could also help quantify improvements in turnout control, injury rates and performance consistency. Interdisciplinary collaborations between dance educators, physiotherapists, and sports scientists may support the development of evidence-based curricula and screening tools that adapt to each dancer's physical capacity. These paths for further investigation hold significant potential for creating safer, smarter, and more individualized training systems that respect the anatomical realities of the dancers' bodies without compromising artistic growth.

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