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2026 Volume 4, Issue 3
Lecture Notes in Education, Arts, Management and Social Science
ISSN:2705-053X

The Impact of Accessory Navicular Syndrome on Ballet Dancers and Intervention Strategies

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Abstract: Ballet dancers face rigorous physical demands, making them susceptible to specific foot pathologies. Accessory Navicular Syndrome (ANS) is an anatomical abnormality that features an extra bone close to the navicular; although it is often asymptomatic in the general public, frequent use of ballet shoes, pointe work and turnout by dancers can make it very serious. Anatomy and Biomechanics of the ANS, particularly the symptomatic Type II variant, and its effect on the function of the posterior tibial tendon (PTT) are examined in this paper. It investigates how ANS is related to impaired mobility, changes in biomechanics, chronic pain, and all kinds of psychological problems, such as anxiety and loss of self-confidence. Specific prevention plans, as well as adjusted training and various stages of treatment for adolescents, adults and the pre-retirement stage are also put forward in this paper. According to the results, although conservative treatment is the first choice, simple excision surgery may have better recovery conditions for these people. Finally, it is hoped that a combination of physical therapy, mental health support, education and publicity can be used to extend the working life and improve the overall well-being of dancers in the dance industry.

Keywords: Accessory navicular syndrome; Ballet dancers; Foot biomechanics; Injury prevention; Dance medicine

Online publication: March 26, 2026

1. Introduction

Ballet has stringent demands on the body, so the dancers are required to have good flexibility, strength and stamina. Dancers are high-performing athletes and are more prone to injury than others [1]. There are many foot and ankle problems; thus, safe exercise and injury prevention are required. Accessory Navicular Syndrome (ANS) is a condition on the inside of the foot near the arch that is caused by an extra bone near the navicular. Most of the time, ANS is not painful in daily life, but ballet dancers are at a higher risk because of the stress of pointe work, external rotation and jumping [2]. The above activities put more stress on the middle arch and thus increase the risk of pain and dysfunction. Dancers with symptomatic ANS have impaired mobility and instability, so they cannot be trained or perform. To relieve the pain, some people unconsciously change their way of moving, such as turning their foot slightly inwards or moving the weight to the outside of the foot. Therefore, there will be some secondary injuries [3]. Dancers may be too much in their hip external rotation or lose proper alignment, thus injuring the knees and ankles. The posterior tibial tendon (PTT) is an important support for the arch and can be damaged. If not handled in time, there will be some problems with the movement in this area. Worse

still, ballet's culture of pushing through pain may make dancers ignore the first signs of injury [4]. By the time they go to the doctor for help, what was once only a small arch pain may have become chronic damage that affects performance and reduces life span.

Therefore, we must take corresponding measures in advance. Good management of ANS in ballet requires knowing its anatomy and function, being aware of the high demands of training, and addressing both physical and mental problems. Early intervention and education need to be carried out so that dancers, teachers, healthcare workers and others can cooperate. The following sections will examine the anatomical basis of the ANS, its impact on ballet technique and the well-being of dancers, as well as various intervention and prevention strategies. Through good prevention, treatment and rehabilitation, the dancers can train safely, reduce the risk of injury, and continue their careers as professional dancers.

2. Anatomical and biomechanical foundations of ANS

2.1. Anatomical characteristics

The accessory navicular bone (also known as the OS tibiale externum or prehallux) is an extra bone that consists of cartilage and is located on the inside of the foot above the arch [5]. The three are: Type II is the type most likely to cause pain and is the most clinically important variant. It is a large, triangular or heart-shaped bone that is joined with cartilage to the navicular and forms a synchondrosis; although it can move slightly, it is also relatively weak. Repetitive stress causes pain, inflammation and other degeneration. Keles-Celik and others have pointed out that prolonged compression of the synchondrosis can cause swelling and even fracture-like signs [6]. Normally, ANS is not to be paid special attention to because most people are asymptomatic. Ballet dancers are especially susceptible to it and may develop Type II due to the circumstances of intensive training. Navicular and attached PTT are to bear the arch. When a dancer is standing on pointe, the PTT and other supports need to bear the whole-body weight through the tip of the shoe. A bump on the outside of the bone presses on the tendon and is thus sore and swollen. Therefore, a minor skeletal abnormality is also a reason for pain in ballet. According to research, the symptoms of ANS are worse during exercise and better after rest [7], and dancers have also reported this.

Prevalence differs among populations. Incidence in the general population is about 4% - 21% [8]. A study of many ethnic groups in Asia found that the proportion of such cases was around 46% across the region, and more than half of the Chinese population had this variant [9]. Dancers of East Asian descent are more likely to have an accessory navicular; therefore, active screening and prevention should be taken in this group. To solve the problem of early detection for these dancers, the training plan can be adjusted or special dance shoes can be worn until the symptoms disappear.

2.2. Biomechanical implications

Dancers with Type II accessory navicular have the PTT on the extra bone pieces and are thus less capable of arch support. Adjust the support of the arch slightly, and thus the forces will change. In ballet, everything must be correct. A weakened arch may cause instability in the ankle and thus lead to a loss of balance and more stress on the foot and ankle. Over time, there may be an imbalance that leads to posterior tibial tendon dysfunction (PTTD), and it is also one of the reasons for chronic flatfoot and difficulty bearing weight. At the end of each jump, there is a stress on the arch; if the arch is not stable, this stress will concentrate at the connection point with the accessory bone. Dancers continue to train despite feeling unwell, so they swell or are still in pain. These problems are more pronounced in the act of plantarflexion. Due to the long-term practice of pointe work, there has been damage to the navicular bone area and pain; as a result, the technique has been modified (e.g., reduced full relevé), and this new way also strains other joints.

Compensation radiates upward. Dancers may unconsciously shift weight to the outside of the foot or reduce hip abduction. These adjustments protect the foot in the short term but cause knee or hip strain. Over time, localized foot problems can lead to knee, hip, and even back pain. Ahonen notes that instability in the arch leads to malalignment in the lower limb joints, increasing overall injury risk. We cannot view ANS in isolation. Understanding its anatomy and

biomechanics is the first step in developing safety strategies.

3. Impact of ANS on ballet dancers

3.1. Limitations in movement and technique

Ballet requires strong, flexible arches. Dancers with ANS often experience limited plantar flexion, pain around the navicular, and instability, making it difficult to maintain proper alignment on pointe. Turnout places additional stress on the feet. When the arch is weakened, during a simple plié or relevé, the foot will pronate. Ahonen observed that arch instability links to misalignments up the leg, and dancers with collapsed arches are prone to knee valgus, shin splints, patellofemoral pain, or Achilles tendinopathy. More frequently, there will be jumps and landings. The end of a landing should be on the toes, then the arch, and finally the heel; if it is unstable or hurts, one may land stiffly or unevenly. To avoid pain, they may not be able to do the rolling movement at all and therefore land on a stiff leg or one foot, increasing the load on the knee and hip. Dancers may subconsciously reduce the height of their jumps or be reluctant to perform certain jump combinations in the show.

Another problem is that the dancers are used to feeling pain. As Russell noted, many ballet dancers are afraid to miss out on auditions, performances and roles and thus ignore the first signs of injury. Under ANS, a dancer may feel slight arch pain but is not aware of it and continues to dance for several weeks or months. Meanwhile, what could have been dealt with by rest and exercise is getting worse. By the time they ask for help, the problems are usually more severe and require a long absence from work, thus shortening their careers. Therefore, early identification and respect for the limits are necessary. Strengthen the intrinsic foot muscles, improve balance, gradually increase the training intensity, and thus help the dancers with ANS continue to dance without injury.

3.2. Pain perception and management

Pain is the main and continuous symptom. It is usually in the inner arch or navicular area, and it will become more prominent under the weight of one's body, such as during pointe work, several jumps and extended rehearsal periods. Initially, there is only a small pain; it is a sharp pull during relevé or when tightening the pointe-shoe ribbon around the navicular bone. The above are the first signs. If it is not treated, the scattered pain will be constant and even interfere with daily life. It is difficult for dancers to distinguish between "normal" pain and nociceptive pain. Ballet training and its environment can affect a dancer's perception of pain; therefore, a dancer may have a high pain threshold and not be aware that it is an injury. Many people do not seek medical attention in time due to the fear of losing training, and only go when their pain is severe. Thus, the relatively small amount is now a chronic disease.

3.3. Psychological implications

If it is not properly managed, the first two physical risks will be PTTD and progressive arch collapse. Chronic stress of the accessory navicular can result in a small tear or degeneration of the tendon. With time, there will be arching even when the dancer is standing still. The arch of the foot is deformed due to arch collapse and causes chronic foot pain and fatigue in daily life. If it is severe, there will be a bone deformity and arthritis in the middle of the foot. If it is not dealt with now, this will become a long-term disorder in the foot.

It will affect people in many ways. Ballet has many demands, and the need to be injury-free is emotionally draining. Dancers will feel frustrated, guilty and anxious after a performance failure or when they think they are lagging behind their classmates [10]. Treatment decisions - whether to have surgery or extend bed rest - are also causes of stress. Many dancers are closely associated with their physical fitness, and an injury will reduce their confidence and cause them to not want to dance anymore. Ballet is very competitive, and as a result, people feel emotionally isolated. Dancers may be ashamed of their injuries for a long time due to fear that others will think they are not putting in enough effort or are not good enough. Psychological stress can worsen the injury; it is known that people who are stressed and anxious have tight

muscles and lower pain tolerance. Address both the body and the mind of ANS. Early intervention, customised training and psychological support can help the dancers avoid serious injury and be healthy in daily life.

4. Prevention

Prevention is a better way than treatment. Not all cases of ANS can be prevented, especially when dancers have weak anatomy, but measures can reduce symptoms and the risk of recurrence. The first and most basic link is early detection of the risk factors for foot injuries. Russell found that regular examinations could find problems among ballet dancers early and thus reduce the number of injuries. Address any problems or discrepancies in an early stage to prevent injury. A collection of injury history and training load is also good. If a dancer has had persistent foot fatigue or slight arch pain after class, it should be considered a warning sign. Based on the above risk factors, we will prepare some individualised prevention plans. A dancer has been diagnosed with an accessory navicular bone, but it is not causing any symptoms; therefore, strengthen the feet through exercises and gradually adjust the pointe work. A dancer who has had navicular pain in the past could be treated with regular physiotherapy. Early screening is not only about the body but also about the mind. When the dancers are in good health, prevention will be more effective.

Gradually increase the level of pointe work to help the foot and arch adjust to the new stress. Teach dancers how to use the correct muscles properly and maintain an aligned body to prevent stress on the navicular. Russell suggests that people start by improving their physical condition and musculoskeletal stability through Pilates. ANS has provided support for the others. Cross-training gives some tissues a rest. The Environment Matters: A Sprung Floor is Better for Dancing on. Dancers cannot always choose the venue for their performances, but the training location should be a good one. Ballet slippers and pointe shoes do not offer much support, so dancers should wear supportive shoes outside of class. Modifications to the training will be significant and should change the structure of the syllabus, daily techniques, other exercises, etc. They have been applied earlier and consistently to reduce the number of injuries, such as ANS, and help the injured recover better. Ultimately, it is hoped that these activities will be integrated into the students' lives so that good health is achieved naturally in the process of study.

5. Treatment

5.1. Adolescents

Since the bones of adolescent dancers are still developing, conservative therapy is generally the first choice. Rest, foot orthotics, ankle braces and taping can help support the PTT and reduce the stress on the inner arch [11]. If the symptoms are severe, a walking boot can be worn for a short time to reduce swelling and then gradually start walking again. It will be difficult to get the adolescents to comply, and many do not want to wear the bulky supports for ballet shoes. There is a lack of coordination between the doctors' recommendations and what is suitable for the school. Many young dancers are improving gradually, but traditional care does not always lead to continuous development. Nguyen and others have found that if the non-surgical treatment continues, there may be a return of pain and thus require surgery later [12]. Late treatment will result in more damage to the tendon than is necessary. If the symptoms have not improved after 6-12 months of treatment, one should see an orthopaedic doctor.

One surgery that has attracted the attention of young athletes is percutaneous drilling to connect the accessory and main navicular bones [13]. It is minimally invasive, with an 80% success rate in adolescents with developing bones, often reducing pain and allowing return to training in about three months. Since it keeps the foot's natural shape intact, it is a strong option for young dancers who need to recover quickly. However, its long-term effects on ballet-specific movement and flexibility still need more research.

5.2. Adults

For adult dancers, treatment must consider pain, career demands, and long-term foot health. Non-surgical options like targeted physiotherapy, ice therapy, and technique adjustments are usually tried first. Strengthening the tibialis posterior and nearby muscles can improve foot function, and custom orthotics may ease arch pressure. But when pain becomes long-term and affects performance, surgery might be needed. Two main surgical options exist: simple excision, which removes the extra bone while keeping the PTT in place, and the Kidner procedure, which removes the bone and repositions the PTT to better support the arch. Wariach et al. found both methods have good outcomes with few issues, but the choice depends on the dancer's body and career goals [14]. Ballet dancers often do better with simple excision because it targets pain without changing foot mechanics much. The Kidner procedure helps those with flat feet but may limit ankle movement, which could affect pointe work. Since recovery is often faster with excision, it is usually the more practical option for professionals looking to return quickly.

5.3. Soon-to-retire dancers

For dancers nearing retirement, the focus shifts from getting back on stage to maintaining comfort and movement. As dance activity decreases, non-surgical care is usually enough: supportive shoes, orthotics, and gentle rehab like hydrotherapy or Pilates. If pain becomes severe and affects daily life, surgery might be considered, but the decision should depend on future activity levels. A dancer who does not plan to stay physically active is better off avoiding surgery. Conversely, a dancer planning to teach or choreograph may benefit from surgery if it helps maintain mobility. In these cases, a well-managed rehab plan is key.

6. Psychological considerations and coping strategies

Injuries such as ANS can cause damage to the body and the mind. Dancers may feel anxious, frustrated, or even lose a sense of self. Taking care of one's mental health is also as necessary as addressing physical illness. Help the dancers understand their injuries and treatment plans so they do not worry and can cooperate better. When dancers know what is going on in their bodies and what to expect from recovery, they will feel more in control. Continuing to participate in dance during recovery is also good. Mental rehearsal - to imagine the choreography or analyse the movement - can activate the brain-body connection [15]. Observing the rehearsals and guiding the younger students, or researching dance, can also help the dancers find a purpose. Friends, teachers and classmates have all given me much life support. Mainwaring and Finney found that social support can motivate people to get better after injury. The culture at the dance studio should be such that injuries are regarded as inevitable parts of the path for dancers, not failures. If there is psychological support in the treatment, the dancers will be more likely to recover mentally and physically and return to dancing with renewed vigour.

7. Conclusion

The conflict between anatomical structure and the aesthetic requirements of ballet is a serious issue that cannot be neglected. The accessory navicular is inconsistent with the demands of turnout, pointe, and jumping. Because ANS disrupts arch stability, it also alters body weight distribution. Historically, ballet training took a one-size-fits-all approach, but today, more personalized teaching is possible. Teachers should develop training plans based on an understanding of each dancer. Regarding treatment, conservative management can be used initially, but when the condition cannot be controlled, surgical treatment should be undertaken in time to prevent further tendon damage. The dancer's own willingness is the most important; they need to understand the pros and cons of both methods before making a decision. The support of teachers and teams is also very necessary because ANS dancers have to deal with psychological pressure and physical pain. Reassurance and affirmation can alleviate the fear.

Finally, there needs to be continuous promotion. ANS is not well-known among dance educators and performers. In the process of learning to dance, I endured the pain caused by ANS for twelve years before being diagnosed with it, and I thought that it was the same as normal training fatigue. I do not think this is a typical situation. The accessory navicular is not a particular problem in the medical field and has no significant impact on daily life; however, it can cause problems for many dancers in the dance world. Therefore, popularising ANS and taking corresponding measures can help many dancers recognise and address it early on, thus extending their professional lives.

Disclosure statement

The author declares no conflict of interest.

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