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Performing arts medicine with a focus on Relevé in Dancers

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Performing Arts Medicine
with a focus on *Relevé* in Dancers

A.B.M.(Boni) Rietveld
2017

Colophon

Performing Arts Medicine
with a focus on *Relevé* in Dancers

A.B.M.(Boni) Rietveld

PhD thesis Medical Centre for Dancers and Musicians, Haaglanden Medical Centre, The Hague, The Netherlands and Leiden University Medical Centre, Leiden, The Netherlands.

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Performing Arts Medicine
with a focus on *Relevé* in Dancers

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in 1952

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Prof. dr. J.M.W. Hazes	EMC, Universiteit Rotterdam

Motto

Whatever you do, do it with passion

Dedicated to

My father and role model in orthopaedics C.F.W. (Kees) Rietveld
June 2nd, 1922 Ede - † January 5th, 2004 Haarlem, The Netherlands

My identical twin grandsons Alexander B.M. and Valentijn H.J. Groen,
May 3rd, 2016 Sydney, Australia

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Chapter 1

General introduction of Performing Arts Medicine and outline of the thesis

1

General introduction of Performing Arts Medicine and outline of the thesis

1 Introductory remarks
2 Definitions of Performing Arts and Performing Arts Medicine
3 Legitimation of Performing Arts Medicine
4 Why dancers and musicians with musculoskeletal injuries require much more time than orthopaedic patients in general in an orthopaedic outpatient department
5 Differences and similarities between performing arts (dance and music) and sports
6 Types of injuries and diseases in dancers and musicians
7 Relevé: a specific physical requirement, peculiar to dance
8 Posterior Ankle Impingement Syndrome (PAIS) and Flexor Hallucis Longus (FHL) tendinopathy in dancers
9 Goals and outline of the thesis

1 Introductory remarks

The subject of this thesis is Performing Arts Medicine in general from an orthopaedic perspective, focussing on some typical dancers' injuries, which cause a painful and usually limited relevé in dancers (see figure 1). The author works in the Medical Centre for Dancers and Musicians (MCDM) in the Haaglanden Medisch Centrum (HMC) in The Hague, The Netherlands. The MCDM is a dedicated expert-centre for prevention, diagnosis and treatment of injured dancers and musicians. His 25 years of experience in the MCDM form the basis of this thesis.

Fig.1: Relevé

2 Definitions of Performing Arts and Performing Arts Medicine

Performing Arts are forms of art in which artists use their voices and / or their bodies, often in relation to other objects (e.g. musical instruments), to convey artistic expression.

Although the Performing Arts include drama, and, to a certain extent, circus, acrobatics (including aerial acrobatics) and artistic sports, like figure skating, gymnastics, rhythmic gymnastics and synchronized swimming, this thesis is limited to (medical problems in) dance and music. In dance both theatrical dance and dance-sports (participatory dance, like ballroom and latin) are included.

The Dutch Performing Arts Medicine Association (Nederlandse Vereniging voor Dans en MuziekGeneeskunde - NVDMG) defines Performing Arts Medicine, limited to dancers and musicians, as "a medical sub-speciality, that formally addresses the prevention, diagnosis and treatment of complaints, both somatic, mental, and social, which influence playing musical

instruments, singing, or dancing; it includes the scientific research of these complaints and of the healthy functioning of these performing artists". [i]
Performing Arts Medicine is not a medical speciality in itself, but an unique specialised field, attracting interest from a variety of medical specialists and health practitioners worldwide, who wish to include assessment and management of performers in their work.

Performing Arts Medicine may be part of any medical speciality, ranging from occupational health, primary health care and psychology to any clinical medical speciality, of which the most common are ENT and phoniatry, hand-surgery, orthopaedic surgery, physical medicine and rehabilitation (PM&R), psychiatry, rheumatology, and sports medicine (in alphabetical order), not excluding any other medical speciality. These medical specialists may be seen as clinical occupational physicians.
Performing Arts Medicine encompasses all allied health care modalities, like body therapies, physio- and manual therapy, podotherapy, and nutrition specialists.

Performing Arts Medicine is a relatively new field in medicine and has medical centres and scientific associations all over the world. In the Netherlands it has its roots in the last three decades of the 20th century. A brief insight into the recent history of Performing Arts Medicine in The Netherlands will be given in Chapter 2, but a detailed historical overview is beyond the scope of this thesis.
Performing Arts Medicine can be summarized as 'Medicine for Artists' and should be distinguished from the creative therapies in which dance and music are used as therapy: 'Arts as Medicine'.

In this thesis Performing Arts Medicine is limited to dancers and musicians, and is discussed from the perspective of (a subspecialty of) orthopaedics.

3 Legitimation of Performing Arts Medicine

Injuries that may be harmless for others, may incapacitate dancers and musicians. Both dance and music require extraordinary and subtle physical and (neuro-)psychological skills and control, acquired during many years of dedicated training and diligent practice. Due to these high and specific demands performing artists are relatively vulnerable: a 'minor injury' may have great impact, physically, psychologically and last but not least 'socio-culturally'. Dancers and musicians have a strong identification with their art form, hence being injured has great

[i] See: www.nvdmg.org

emotional influence and often means a complete loss of identity and self-esteem. In general this fact is insufficiently acknowledged by health practitioners, and in 'modern' medicine there is usually insufficient time and expertise to analyse in depth their medical problems and complaints. As a consequence treatment may be *"professionally adequate, but does not take into account the emotional and functional demands and expectations of the performing artist, leading to unsatisfactory results".* [ii]

4 Why dancers and musicians with musculoskeletal injuries require much more time, than orthopaedic patients in general in an orthopaedic outpatient department

If their *'emotional and functional demands and expectations'* are properly addressed, dancers and musicians with musculoskeletal injuries require more time in an orthopaedic outpatient department, than orthopaedic patients in general, because of four reasons:

1 Specific dancers' and musicians' injuries

Because of the extraordinary demands of dancing or playing a musical instrument, dancers and musicians present in the clinic with specific injuries. To recognise, prevent and treat these injuries, not only a thorough general orthopaedic expertise is required, but also a profound knowledge and understanding of the different dance-styles and (the demands and technique of playing) musical instruments. It is not realistic to expect this "artistic" expertise to be mastered by general health care providers. On top of a subtle, general orthopaedic patients' history and physical examination, extensive, additional examination is required in the different dance- or ballet-positions, or while playing the musical instrument.. This time-consuming performing-arts-specific examination is required in dancers and musicians only and is normally not necessary in general patients in an orthopaedic outpatient department.

2 Minimal injuries have maximal impact

Due to the high and specific demands in dance (mainly the lower extremity) and in musicians (mainly the upper extremity) a minimal injury may cause a maximal limitation for performing their art form, and will be noticed by the dancer- or musician-patient at an unusually early stage or in a limited form (forme fruste). This makes diagnostics in dancers and musicians complex, since they may already be incapacitated by an injury, long before imaging techniques detect abnormalities. For that matter the presence of abnormalities at imaging might be perfectly normal for that person, potentially causing a Victim Of Modern

[2] Dr.Olaf S.van Hees, *Beleidsnota Gezondheidszorg voor de Kunsten*, 1991

Imaging Technology (VOMIT).[1] Listening to the patient, observation and knowledge of performing arts, as well as of the physiology and anatomy of the musculoskeletal system by the physician are therefore essential. Hence the attending orthopaedic surgeon has to rely on an even more precise than normal, extensive, time consuming patients' history and subtle, meticulous physical, orthopaedic and neurological, examination with often intricate observation of motion or even dancing or playing the instrument provoking the symptoms.[2] It will be obvious this requires considerable time per consultation.

3 Operating less implies explaining more

Since in both dancers' and musicians' injuries surgical treatment is rarely indicated, conservative treatment is the first choice, and often the only option. This implies the attending physician needs to have adequate communication skills to explain the injury and its possible causes, and give advice on how to deal with the injury, how to prevent worsening of the condition (secondary prevention), how to recover from the musculoskeletal complaint, preferably without completely stopping dancing or making music. Finally, the health professional should know how to prevent recurrence (tertiary prevention) (see table 1). Time spent on the latter is mandatory for both recovery and prevention, certainly in this dancers and musicians group.

Table 1	**Prevention**
Primary	Before injury has occurred
Secondary	After injury has occurred, to prevent it from getting worse
Tertiary	After injury has occurred and been treated, to prevent it from happening again

4 Respect for the artists' passion

Dealing with dancers and musicians as patients requires a special attitude of the attending physician. The artistic drive to dance or make music is so immense, that dancers and musicians - professionals and amateurs alike - develop an exceptional, also emotional, relationship to their art form. It is their passion, the essence of their life, their psychological identity, and - of course for the professionals only - their living. This results in a great motivation for reintegration, close concern with the healing process, assertiveness (manifesting itself in a lack of confidence in health care providers in general), and an active participation in the search for a solution of their health issues. Only by approaching the performing artist with understanding, patience, medical and artistic knowledge, open communication and, last but not least, respect and empathy for the artists' passion, can a good doctor-patient relationship be established and medical shopping prevented.

5 Differences and similarities between performing arts (dance and music) and sports

The differences and similarities between performing arts and sports are to be explained, emphasising the need for clinical studies specifically and exclusively in dancers and musicians, since the demands and expectations of these passionate performing artists are incomparable to any other activity, with a guarded exception for certain top-sports, especially the artistic sports, and then in particular rhythmic gymnastics.

"The primary aim in the arts is to produce beauty, something with positive aesthetic value. This is the intrinsic practice of art. The intrinsic aim or goal of sport is winning and beauty is a kind of by-product". [3]

"Dance is "about" something, not just a sequence of movements. Sport is not. E.g. gymnastics can be aesthetic, but it is not an "Art". In gymnastics do not look for the meaning, look for the use. Dance means different things in different context". [4]

In performing arts the goal is artistic value and communication: the execution of dance or music is what it is all about. In dance the performance must seem effortless, the grade of difficulty is irrelevant, and the communication is mainly visual with a supporting auditory component. *"It takes an athlete to dance, but an artist to be a dancer".* [iii] Also in music the goal is communication. The performance itself is primary, and the execution must be perfect with a mainly auditory and supporting visual component.

In all sports the goal is winning, and the achievement is essential. In cyclic-sports (cycling, rowing, running, skating) and game-sports (soccer, and other ball or team-sports) the distinction between sports and the performing arts (dance, music) is obvious: the goal in these sports is competition, not visual aesthetics.
The distinction between artistic-sports (gymnastics, rhythmic gymnastics, figure skating) and sportive arts (circus, (aerial) acrobatics, dance-sports: participatory dance, like ballroom, latin) is less clear. In artistic sports, although the execution and grade of difficulty of certain positions, moves and turns, are essential and must be perfect, the primary goal is competition. In sportive arts the aesthetic value is more important.

[iii] Quote: Shanna LaFleur

6 Types of injuries and diseases in Dancers and Musicians

Performing Arts Medicine includes two major groups of injuries and diseases:

- those caused by dancing, playing musical instruments, or singing itself: the occupational diseases and injuries.
- all those acute and chronic injuries and diseases, which are not caused by or related to dancing or playing a musical instrument, but which have other causes or are acquired in other activities of daily life (ADL), and which may hamper performance of dancers or musicians (e.g. hypermobility, osteoarthritis, trauma).

7 *Relevé:* a specific physical requirement, peculiar to dance

To a certain extent the athletic and sometimes acrobatic requirements may be equal in dance and artistic sports, but certain foot and ankle positions and movements are unique to dance. As a consequence, the results of treatment of certain, presumably the same, orthopaedic injuries in sports may not be extrapolated to dance, and have to be studied in dancers exclusively. Very much the same applies to injuries in musicians.

One of the pioneers of orthopedic dance medicine is prof. E. (Eivind) Thomasen from Aarhus, Denmark. His book "Diseases and Injuries of Ballet Dancers" published in 1982, was one of the starting points in Dance Medicine .[5] In the introduction to his book Thomasen states that *"these injuries are peculiar to dancers, because dancers' positions and movements are different from 'normal' positions and movements in sports and daily life".*

Figure 2: Dancing on pointe ("spitzen" or "sur les pointes")

Relevé (see figure 1) is an example of the not always conspicuous differences between dance and sports, with a guarded exception for gymnastics, especially rhythmic gymnastics, which combines elements of ballet, gymnastics, dance, and apparatus manipulation (rope, hoop, ball, clubs, ribbon and freehand).

Relevé is an ankle-foot position peculiar to all forms and styles of dance, around the world, and is required in virtually each choreography. Relevé requires maximal plantarflexion (90°) in the ankle or talo-crural joint, just like in dancing on pointe, which is predominantly used in ballet (see figure 2).

In dance, both in relevé and *on pointe*, the ankle is frequently, actively and prolonged forced into extreme plantar flexion. Following

mechanism-based reasoning, this means that the foot-ankle joint complex is fully weight-bearing in the end range of joint motion *(close-pack),* with the consequence that forces are transmitted directly through the contacting bones with neither intrinsic shock damping by compensatory joint motion, nor extrinsic shock absorption by the shoe or the floor. This leads to repetitive peak stress on the contacting bony structures in the back of the ankle.

In some sports extreme plantarflexion of the ankle is required periodically and suddenly in a passive manner (by external force, e.g. soccer during certain forms of kicking) or briefly in an active manner (e.g. rhythmic gymnastics and other artistic sports), but never in the controlled, persistent, extreme, active and fully weight bearing manner, as is so frequent in dance.
In kicking a ball the talocrural and subtalar joints are non-weight-bearing, hence there is no tendency of the talus (talocrural) and calcaneus (subtalar) to slide posteriorly, adding to the impingement. Secondly, while kicking, the calcaneus is not pulled up by the triceps surae.
That this is important is biomechanically logical and is illustrated by the fact that in testing for posterior ankle impingement (plantar flexion test), the pain will mainly be provoked if the calcaneus is pushed up by the examiner simultaneously. Of course in rhythmic gymnastics and other artistic sports, as well as in many ADL activities this happens only briefly, but the persistent, repeated combination of these factors is unique to dance.

8 Posterior ankle impingement syndrome (PAIS) and flexor hallucis longus (FHL) tendinopathy in dancers

The biomechanical factors described in the paragraph above may contribute to the frequency of posterior ankle impingement syndrome (PAIS) in dancers, which is a typical and common dancers' injury, sometimes referred to as Dancers' heel. [6]
In dancers FHL tendinopathy (posteriorly and plantarly to the medial malleolus and sustentaculum tali) regularly [7;8] coincides with PAIS and sometimes is referred to as Dancers' tendinitis, a diagnosis coined by William G. Hamilton, MD. [9;10]

The etiology of FHL tendinopathy in dancers is not fully understood. It may be related to anatomical variations, [5;11] faulty dance-technique, [12] and possibly FHL activity in certain dance-positions and jumps.

Many dancers end their performance careers before they have reached the age of 35, an age at which other professionals are reaching their most productive years. [iiii]

[iiii] See: www.iotpd.org the website of the International Organization for the Transition of Professional Dancers

The specific functional demands, the emotional impact of an injury and the brevity of a dancers' career are part of the legitimation of dance medicine. The importance of the relevé-position (see figure 1) in all dance-styles and the frequent presenting complaint of limited and painful relevé, justify a profound knowledge of optimal treatment and outcomes of PAIS and FHL tendinopathy in dancers and form the ratio for the dance-specific parts of this thesis.
Given the specific and different functional demands of dance compared to sports, studying the treatment outcome for PAIS and FHL tendinopathy in dancers specifically is of paramount importance.
Hence, the emphasis in this thesis is on dance-injuries and more specifically on some orthopaedic causes of a limited and painful relevé in dancers, including their treatment options and outcomes in dancers.

9 Goals and outline of the thesis

The goals of this thesis are:

1 Enhancing awareness for Performing Arts Medicine in dancers and musicians from an orthopaedic perspective;
2 Drawing attention to specific, but common musculoskeletal problems in dancers, addressing the importance and uniqueness of the relevé position in dance (see figure 1). Evaluating the results of conservative and operative treatment of a limited and painful relevé due to posterior ankle impingement syndrome (PAIS) and flexor hallucis longus (FHL) tendinopathy in dancers;
3 Evaluating some structural deformities and specific, miscellaneous and rare forefoot and tarsal conditions, causing a limited and painful relevé in dancers, including their treatment options and outcomes;
4 Summarising the findings and their clinical and dance-medical relevance. Giving historical and future perspectives in Performing Arts Medicine in The Netherlands, and defining areas for future research.

Outline of the thesis.:

After a historical overview of Performing Arts Medicine in The Netherlands (chapter 2) the scientific content of the thesis is written in four parts:

In Part 1 (chapters 3 - 6) orthopaedic Performing Arts Medicine, limited to dancers and musicians, is introduced with a general (chapter 3) overview of orthopaedic Dance Medicine and Musicians' Medicine, prevention and rehabilitation of complaints in musicians and dancers, including dance specific graded rehabilitation (chapter 4). Some aspects of aetiology of common

dance injuries related to hyperpronation were investigated by studying the incidence of symptoms related to foot hyperpronation in dancer-patients in a retrospective study of 2,427 dancers' charts. The potential correlation between the patient's calcaneal angle and severity of hyperpronation was evaluated by measuring the calcaneal angle and correlating it with a clinical grading scale based on the Hübscher maneuver in 24 new dancer-patients presenting to the clinic with hyperpronation related symptoms (chapter 5). The usage and effectiveness of orthotics in the management of symptomatic hyperpronation among dancers was studied in a prospective cohort study of dancer-patients, who were prescribed orthotics for symptoms related to hyperpronation. These patients filled out questionnaires addressing perceived effectiveness of the orthotics and their longitudinal medial arch angle of the foot was measured using the Foot Build Registration System (FBRS), both barefoot and while wearing the orthotics. In order to obtain longitudinal data regarding the dancers' compliance with, and subjective evaluation of, wearing orthotics, a second retrospective study was conducted among 105 participating dancers (chapter 6).

In Part 2 (chapters 7 - 9) the results of conservative and operative treatment (both open and endoscopic) of limited and painful relevé due to posterior ankle impingement syndrome (PAIS) and flexor hallucis longus (FHL) tendinopathy in dancers only are studied in a systematic review, searching PubMed, Embase, COCHRANE, CINAHL, Web of Science, and (in French) ScienceDirect databases in October, 2016 (chapter 7).
The results of open surgery for PAIS and FHL tendinopathy in dancers are described studying the hospital records of ankle surgeries for these diagnoses in consecutive patients, performed by the author between 1989 and October 2016. Matching patient files were retrieved to filter surgeries performed in dancers only and endoscopic surgeries were excluded (chapter 8).
In a small, retrospective, descriptive cohort study the open procedure is compared with the endoscopic procedure for PAIS and FHL tendinopathy in dancers only. For this study, to avoid a learning curve effect, it was decided to study the first 20 consecutive open procedures in 16 dancers with PAIS and FHL tendinopathy performed in the period May 1991-December 1996, and to compare them with the first 19 consecutive endoscopic procedures in 16 dancers with the same diagnoses in the period February 2002-July 2003.
All patients were dancers, had failed conservative treatment, and were operated by the author. The post-operative outcomes were reviewed by studying the patient files, clinical evaluation, AOFAS scoring, and administered a dance-specific questionnaire (chapter 9).

In Part 3 (chapters 10 - 12) limited and painful relevé in dancers due to some miscellaneous and rare forefoot and tarsal conditions is discussed. The first case report of Freiberg's disease in a

dancer serves to discuss the orthopaedic and artistic implications of managing this disease in a young, active, adolescent dancer, and a new surgical treatment is presented (chapter 10).
In a retrospective case series consecutive dancer-patients, diagnosed clinically and radiologically with a tarsal coalition, were identified. Data on presentation and treatment in our centre were extracted from the medical records. The dancers were interviewed regarding their perceived satisfaction and ability to participate in their desired dance activities (chapter 11).
The patient files and radiographs of a consecutive case series of six dancers (10 feet), who were treated in our clinic for a symptomatic accessory navicular, were studied. The final outcomes, as documented in the files, were confirmed by telephone interview, inquiring if they were able to resume their dance activities without complaints or restrictions and if they had residual symptoms (chapter 12).

In Part 4 (chapter 13) a general discussion, suggestions for future research and a future perspective of Performing Arts Medicine in The Netherlands are given.

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Chapter 2

Historical overview of Performing Arts Medicine in The Netherlands

Historical overview of Performing Arts Medicine in The Netherlands

2

1 Introduction
2. Historical overview of Performing Arts Medicine in The Netherlands
3. Short background of the Medical Centre for Dancers and Musicians (MCDM)
4. Clinical research in the Medical Centre for Dancers and Musicians (MCDM)

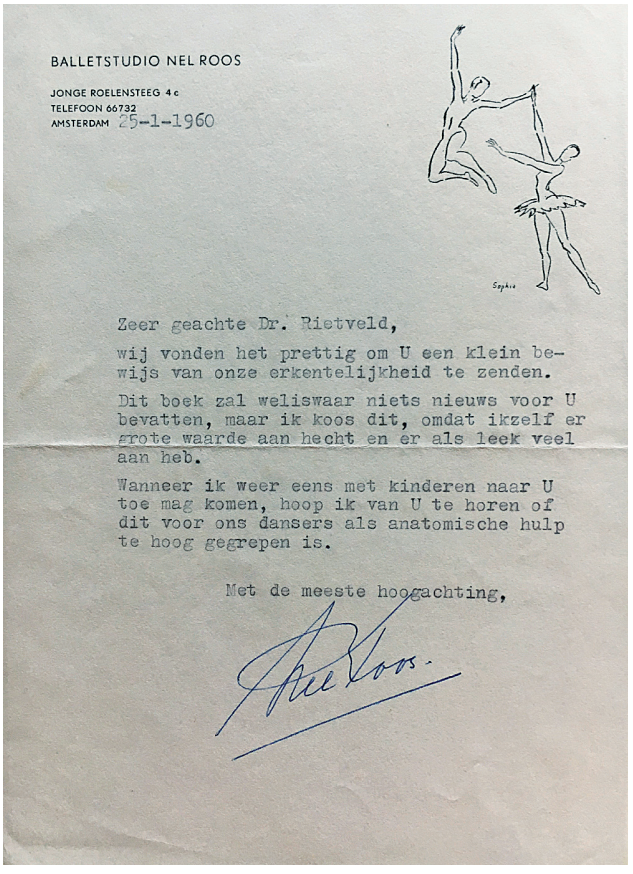
1 Introduction

Performing Arts Medicine is a relatively new field in medicine, and since one of the goals of this thesis is to enhance awareness for Performing Arts Medicine in general, a concise historical perspective and overview of Performing Arts Medicine in The Netherlands is appropriate and deserves a place in this thesis. It must be emphasized that this overview is from a personal perspective.

2 Historical overview of Performing Arts Medicine in The Netherlands

As early as 1960 C.F.W. (Kees) Rietveld (2-6-1922 - † 5-1-2004), orthopaedic surgeon in Haarlem and father of the author, took care of the dance-students of the Balletstudio Nel Roos, a predecessor of the Dutch National Ballet Academy, nowadays part of the Theatreschool in Amsterdam (see figures 1 and 2).

Fig. 1: C.F.W. (Kees) Rietveld (2-6-1922 - † 5-1-2004), orthopaedic surgeon in Haarlem



BALLETSTUDIO NEL ROOS

JONGE ROELENSTEEG 4 c
TELEFOON 66732
AMSTERDAM 25-1-1960

Zeer geachte Dr. Rietveld,

wij vonden het prettig om U een klein bewijs van onze erkentelijkheid te zenden.

Dit boek zal weliswaar niets nieuws voor U bevatten, maar ik koos dit, omdat ikzelf er grote waarde aan hecht en er als leek veel aan heb.

Wanneer ik weer eens met kinderen naar U toe mag komen, hoop ik van U te horen of dit voor ons dansers als anatomische hulp te hoog gegrepen is.

Met de meeste hoogachting,

Nel Roos.

Figure 2: Letter from Nel Roos, accompanying her gift: a book "Anatomy and Ballet" by Celia Sparger.

In the Netherlands Performing Arts Medicine has its roots in the last three decades of the 20th century with medical pioneers in several cities:

- Amsterdam: C.C.(Constant) Delprat, MD †, prof. dr. C.N.(Niek) van Dijk MD, PhD, prof. dr. R.(René) Marti MD, PhD, and A.H.(Toine) Schermer, MD,
- Beetsterzwaag: K.H. (Kees Hein) Woldendorp, MD,
- Enschede: dr. W. (Willem) Kersing, MD, PhD,
- Hilversum: P.A.H.M.(Pieter) Goderie, MD,
- Hoogeveen: G.J.(Jan) Sonneveld, MD (originally Rotterdam),
- Maastricht: dr. M.D.F. (Marjon) van Eijsden, MD, PhD, (originally Rotterdam)
- Rotterdam: prof. dr. S.E.R. (Steven) Hovius, MD, PhD
- The Hague: dr.O.(Olaf) van Hees, MD, PhD, and A.B.M. (Boni) Rietveld, MD, BMus, and more recently: G.J.F (Gert-Jan) de Haas, MSc, BMus, neuro-psychologist and dr.J.D.(John) Macfarlane, MD, PhD,
- more recently in Amsterdam: D.(David) de Boer, MD, and in Leiden: dr.E.M.(Esther) van Fenema, MD, PhD, BMus.

Probably the honour of the first Dutch thesis in Performing Arts Medicine (written in 1991) goes to O.S.(Olaf) van Hees, MD, PhD, who researched hearing problems in musicians during his work as an occupational physician for the Royal Military Band and the Residency Orchestra, the Symphony Orchestra of The Hague.[1] Another pioneer in the field of hearing problems in musicians is audiologist J.A.P.M.(Jan) de Laat MSc, PhD, in Leiden University Medical Centre. Dr.J.B.(Joop) van Deinse, MD, PhD † in the Westeinde Ziekenhuis in The Hague and prof. dr.P.H.(Helbert) Damsté MD, PhD † in Utrecht were two early pioneers in the field of phoniatry, taking care of the professional voice.

Some pioneers in the field of allied healthcare for performing artists:
Bendt Schortinghuis was the physiotherapist of the Nederlands Dans Theater, at that time under the artistic direction of Jiří Kylián, when the author started his work as an orthopaedic surgeon for dancers with that company in 1987.
In 1978 Ans Samama, a bodytherapist for musicians (*oefentherapie Mensendieck*) wrote the first edition of her book "*Muscle control for musicians*".[2] She trained several of her younger colleagues, like Marjon Kuijers and Marja Mosk.
Still active physiotherapists for dancers are Bert de Boer, John ten Kulve, Marco Lysen, Menno de Vries, and Ted Willemsen and their colleagues of the Keizersgracht 790 (recently moved to Nieuwe Keizersgracht 45) in Amsterdam. The first bodytherapist (*oefentherapie Mensendieck*) for dancers is Marleen Grol in Amsterdam.
Early physiotherapists for musicians: J.(Hans) Boschma, (embouchure specialist and founder of the website: www.embouchure.nl), G.O. van de Klashorst, (dispokinesis for musicians), R.(Rob) Nolet (Foundation "*Sanitas in Musica, Musicis Sanitas*"in Amsterdam).
And last but not least, certainly a Dutch scientist particularly worth mentioning is prof dr. J.N.A.L. (Joris) Leijnse, PhD, anatomist and hand-biomechanist at the University of Ghent, Belgium (originally based in Rotterdam), who did (and does) ground-breaking research on (primary) Focal Hand Dystonia in Musicians (FHDM), since successfully and cum laude defending his thesis "*Finger exercises with anatomical constraints*" in 1995. [3-18] For this thesis Leijnse won the prestigious 'Anna-prijs' award of the Dutch Orthopaedic Association (Nederlandse Orthopaedische Vereniging - NOV) in 1996.

The first Performing Arts Medicine Symposion in The Netherlands was organized by the Phia Berghout Foundation, during the first World Harp Congress, on July 11th, 1983, in Maastricht. The title was: "Medical and sociological aids to performing musicians". The author, having recently finished his dance-medicine training in New York, had the privilege to be its symposium moderator. The World Harp Congress, Inc., a private non-profit organization, was founded in

1981 as an outgrowth of the annual International Harp Weeks, held in The Netherlands for twenty years under the leadership of Phia Berghout † (see figure 3) and Maria Korchinska †. [i]

Figure 3: S.R (Phia) Berghout in 1933 after being appointed harpist of the Concertgebouw Orchestra

In The Netherlands, around that time other initiatives in Musicians' Medicine emerged, like symposia organized by the Foundation "*Medici voor Musici*" since 1985 in Hilversum, and the "Harm and Harmony in Musicians' symposia" in Amsterdam, organized by the Foundation "*Sanitas in Musica, Musicis Sanitas*" since 1988.

Internationally in that same period the first issue of Medical Problems of Performing Artists (MPPA), a peer-reviewed medical journal devoted to performing arts medicine, appeared in 1986, the Performing Arts Medicine Association (PAMA) was founded in 1989 in the USA, and the International Association for Dance Medicine & Science (IADMS) was formed in 1990.

The Medical Centre for Dancers and Musicians (MCDM) was founded in the Westeinde Ziekenhuis in The Hague on April 1st, 1993. This large teaching hospital, nowadays part of Haaglanden Medisch Centrum, had the vision to facilitate this new initiative, which was such a novelty, that its official opening was covered by several national newspapers, Dutch radio and

[i] Phia Berghout, December 14th, 1909 Rotterdam - March 22nd, 1993 Doorn, was the first harp teacher of the author. Maria Korchinska, February 16th, 1895 Moscow - April 17th, 1979 London.

television, and even made it to a CNN news item. Several photographs of the interior of the MCDM appeared in a British textbook on hand-problems in musicians. [19]
All this exposure and press coverage not only gave a boost to Performing Arts Medicine in The Netherlands, but even more it helped to decrease the taboo of dancers and musicians openly admitting that injuries were present.

Between 1994 and 2004 small scale evening symposia in Dance Medicine were organised by the Dutch Healthcare for Dancers Foundation (Stichting Gezondheidszorg voor Dansers, SGD) initiated by Prof.Frederike van Wijck BSc, MSc, PhD, and Margot Rijven of the Amsterdam Theatreschool (Amsterdamse Hogeschool voor de Kunsten, AHK). The SGD co-organized two conferences, which were not primarily medical (*'Not Just Any Body', a global Conference to advance Health, Wellbeing and Excellence in Dance and Dancers*, November 12th - 14th, 1999, and '*Not Just Any Body & Soul', Facing the Challenge,* November 6th - 8th, 2003). On September 25th, 2004, the SGD celebrated its 10th anniversary with a full day symposium, and a farewell to several founding board-members, including Boni Rietveld, who had served on its board for a decade, with Paul Bronkhorst, representative of the Stichting Omscholingsfonds voor Dansers / IOTPD, and A.H.(Toine) Schermer, MD, occupational physician.

Shortly after that, October 27th - 31st, 2004, the first course "*Dance, Music & Medicine*" for Dutch physicians took place in Burg Feistritz in Feistritz am Wechsel in Austria, as an initiative of several Dutch family physicians, including J.(Jan) Krijgh, MD, and R.(Roel) van Kuppevelt, MD. During this first course it was decided to establish a Dutch Performing Arts Medicine Association, which resulted in the foundation of the "*Nederlandse Vereniging voor Dans- en MuziekGeneeskunde" (NVDMG)* half a year later on April 1st, 2005. The NVDMG adopted the journal Medical Problems of Performing Artists (MPPA) as its official publication, and organizes two or three symposia and one course per year: in 2017 the 25th symposium was held in Tilburg, and the 14th course in Burg Feistritz (see: www.nvdmg.org).

In 2001 the Dutch Healthcare for Musicians Foundation (Stichting Gezondheidszorg voor Musici, SGM) was founded, resulting in a website for injured musicians, an initiative of Marc Stotijn (see: www.muziekenzorg.nl).

Thanks to the efforts of the author several typical dance-medicine-words (like *dancers' heel and*

dancers' tendinitis), and musicians'-medicine-words (like *drummers-wrist, musicians' cramp* (focal dystonia) and *violin chin*), have made it into the famous and largest Dutch medical dictionary "*Pinkhof*". [20]

A more detailed historical overview of Performing Arts Medicine in The Netherlands is beyond the scope of this thesis, but might be the subject of future medical historical research, preferably while most of its pioneers are still accessible.

Due to recall bias of the author the above enumeration is by no means intended to be precise or complete, and the author apologizes for any mistakes or anyone unintentionally forgotten.

3 Short background of the Medical Centre for Dancers and Musicians (MCDM)

The MCDM was founded by Boni Rietveld in 1993, with strong support of dr.J.D.(John) Macfarlane, MD, PhD, dr.R.J.(Rob) Sanders MD, PhD (past-head of the orthopaedic department of the Westeinde hospital), H.M.A.(Henk) Schippers, † MBA (past-director of the Westeinde hospital) and drs.A.Th.(Dolf) Schweizer, † MD (past-director of Leiden University Medical Centre). (see figure 4)

Figure 4: The pictogram of the Medical Centre for Dancers and Musicians (MCDM) was designed in 1993 by Studio Dumbar, combining elements of orthopedics, dance and music, in the style of the icons used on the stationery of the Westeinde Ziekenhuis in The Hague, the hospital where the MCDM was founded on April 1st, 1993.

The MCDM is a dedicated Performing Arts Medicine (orthopaedic) referral and expertise centre in the Haaglanden Medical Centre (HMC) in The Hague, consulted by dancers and musicians only. The MCDM certainly is not for professionals only: the passion for dance and / or music is pre-eminent and the non-discriminatory expertise in the MCDM is available for all dancers and all musicians, of all dance-styles and all musical instruments, professionals, teachers, students and amateurs alike. All consultations are covered by the Dutch health insurance system (provided the patient is referred by a family physician or medical specialist), and all have the same waiting time for a first consultation, although next to medical emergencies, there is a place for cultural or artistic urgency ("*the show must go on!*"), also for amateurs.
No distinction is made between injuries acquired during activities of daily life or during work: the Netherlands do not have a system of workers' compensation. [ii]

[ii] Schippers HMA, Rietveld ABM. Danserspoli is geen bedrijvenpoli, Medisch Contact, januari 1998.

In The Netherlands in the year 2000 the Dutch health insurance system accepted a specific remuneration for the orthopaedic care and cure of dancers and musicians in the MCDM.[iii] This special fee was accepted by the government and all health-insurance companies because of the following three reasons:

1 the author was able to convince the appropriate authorities and health insurance companies of the uniqueness of dancers and musicians as patients, and of the fact that consultations for these demanding patients require much more time than average;
2 in Dutch orthopaedics the emphasis is (increasingly) on operative treatment, which is more rewarding and less time consuming in the outpatient department than prevention or conservative treatment. In performing artists prevention is the goal and treatment is predominantly conservative;
3 the author is taking care of dancers and musicians exclusively and is not consulted by any other patients, which means that no compensation (either in time or money) is possible by less time consuming consultations or more rewarding surgical treatment.

So far the MCDM is the only clinic permitted to charge this special fee, allowing the author to continue to devote his entire professional life as an orthopaedic surgeon in the MCDM exclusively to dancers and musicians.

4 Clinical research in the Medical Centre for Dancers and Musicians (MCDM)

Due to the concentration of dancer- and musician-patients, over the past 25 years the author was able in person to see, diagnose and treat literally thousands of this specific subgroup of orthopaedic patients, expanding his personal experience and establishing an immense and unique database with his findings, ranging from prospectively collected demographic and dance- resp. music-specific data to a documented, clinical medical diagnosis, treatment and outcome.
Part of the data concerning 7,000 dancers are digitalised (see below), but all musicians' data are still on paper in patient-files, waiting to be analysed. One of the major goals for the near future is to (establish funding to) scientifically explore these files.

Quite a few incidental studies have been performed on this dancers'- and musicians'-database, sometimes resulting in scientific publications, like the studies in several chapters of this

[iii] Tarief 03.9408: orthopaedische begeleiding en behandeling van dansers en musici in een daartoe speciaal ingericht medisch centrum. Dit tarief mag alleen gehanteerd worden met toestemming van de CTMS (Commissie Tarieven Medisch Specialisten)

thesis, but more often resulting in oral presentations only, and not in scientific publications. An example is a study on Mann cheilectomy in degenerative hallux rigidus in dancers, which was presented at several symposia, but, apart from an abstract, never resulted in a scientific publication. [21] This is due to the fact the MCDM is a dedicated department in a general hospital, lacking academic support: the focus is exclusively and entirely on dancer- and musician-patient care and cure. Other incidental studies, not resulting in a scientific publication, include femoro-acetabular impingement (FAI) in dancers, and in musicians: sub-acromial pain syndrome (SAPS) in flautists, injuries in string-players, surgical treatment of ulnaropathy and rhizarthrosis, or the use of silver-ring splints for hand problems, like hypermobility and osteoarthritis in the fingers, to name a few.

After acquiring IRB approval, an observational study on injuries in dance and musician arts medicine began in 2015, called 'PASSION-MD' ("Performing Arts Society Study In and Of the Netherlands - in Musicians and Dancers"). PASSION-MD is a 25 years cohort study containing the clinical data of the thousands of dancer- and musician-patients consulting the Medical Centre for Dancers and Musicians, since its inauguration on April 1st, 1993.
The goal of PASSION-MD is to extract retrospectively as much information as possible from these patient-files, and submit it in articles to the scientific Performing Arts Medicine community. That this is an ambitious goal is illustrated by the fact that it took 18 weeks of more than full time work for one diligent medical student to enter most of the relevant data of the first 7,000 dancers in the PASSION-D database. So, part of this material is at present available for evaluation. The music-arm of the study, PASSION-M, has still to be started.

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Painting "dr.Rietveld" by Natalia Horecna, 2005

PART 1 (chapters 3-4a-4b-5-6)

General overview of orthopaedic dance- and musicians' medicine,
some aspects of aetiology, diagnostics, conservative management, rehabilitation
and prevention of injuries in dancers and musicians

Chapter 3

Dancers' and musicians' injuries

A.B.M.(Boni) Rietveld

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3 Dancers' and musicians' injuries

Abstract

This overview is based on the over 30 years of performing arts medicine experience of the author, an orthopaedic surgeon who devoted his professional life entirely to the prevention, diagnostics, and treatment of dancers' and musicians' injuries. After a short introduction of the specific demands of professional dance and music making, it describes some general principles of orthopaedic dance medicine and causes of injuries in dancers. The relation of dance injuries with compensatory mechanisms for insufficient external rotation in the hips is explained, as well as hypermobility and the importance of 'core-stability'. As a general principle of treatment, the physician must respect the 'passion' of the dancer and never give an injured dancer the advice to stop dancing. Mental practice helps to maintain dance technical capabilities. The specific orthopaedic dance-medicine section deals with some common injuries of the back and lower extremities in dancers. An important group of common dance injuries form the causes of limited and painful 'relevé' in dancers, like 'dancer's heel' (posterior ankle impingement syndrome), 'dancer's tendinitis' (tenovaginitis of the m.flexor hallucis longus) and hallux rigidus. The second half of the overview deals with the general principles of orthopaedic musicians' medicine and causes of injuries in musicians, like a sudden change in the 'musical load' or a faulty playing posture. Hypermobility in musicians is both an asset and a risk factor. As a general principle of treatment, early specialized medical assessment is essential to rule out specific injuries. Making the diagnosis in musicians is greatly facilitated by examining the patient during playing the musical instrument. The playing posture, stabilisation of the trunk and shoulder girdle and practising habits should always be checked. Musicians in general are intelligent and the time spent on extensive explanation and advice is well spent. In overuse injuries, relative rest supported by 'mental practice' is effective. The specific orthopaedic musicians' medicine section deals with some common injuries of the neck and upper extremities, like (posture related) cervicobrachialgia, and thoracic outlet syndrome. An important group of causes of musicians' injuries form the entrapment neuropathies (especially ulnaropathy), osteoarthritis of the hands and hypermobility.

Keywords 'Core-stability' . 'Dancer's heel' (posterior ankle impingement syndrome) . 'Dancer's tendinitis' (tenovaginitis of the m.flexor hallucis longus) . Dancing . Entrapment neuropathies . Hallux rigidus . Hypermobility . Mental practice .Music . Osteoarthritis of the hands . Performing arts medicine . Ulnaropathy

Introduction

Dancers and musicians (professionals and amateurs) together constitute approximately 19% of the Dutch population. Because of their high and specific physical demands, dancers and musicians are vulnerable for injuries. Long and hard exercise and training are required for artistic top performances under the scrutiny of the audience and the stress of the media. Dance requires maximal propriocepsis and coordination, music extreme precision, and fine motor control, in both these are combined with stamina and perseverance. During a symphony, the fingers of the violinist run a marathon; the same applies to the pianists' fingers in a solo concerto. Dancing is top sport on the square metre, music on the square centimetre.

This overview deals with injuries due to dancing or music making only, not with injuries acquired during other activities. However, because the sequelae of injuries acquired in daily life can be detrimental for dancers and musicians, even more dedicated care and cure are needed in their treatment, preferably by physicians trained in Performing Arts Medicine, who are aware of the specific demands of dance and music.

DANCERS' INJURIES

General principles of orthopaedic dance medicine

Introduction

Of the many dance forms, this survey deals with theatrical dance only, including (classical) ballet, jazz, modern, show musical, tap, and international (folk-)dance and not with ballroom, latin, or hiphop. There are 7,000 professional dancers (including teachers), 1,400 vocational dance students, and approximately 1,300,000 amateurs (including ballroom and latin). The language of ballet is French. Professional dancers and dance students do a daily training every morning, 6 days a week. The first part of this 'class' is called '*barre*', after the support railing in the ballet studio. New choreographies are rehearsed in the afternoon under the

Figure 1 Attitude: bent knee (Emalie Fisser)

supervision of the choreographer or ballet master. On top of this, there are three or four evening performances, up to eight shows a week for musicals. Hypermobility is an asset and a prerequisite for dancers, who usually score 5 or more points of the nine Beighton criteria. The control and coordinaton of this hypermobility is achieved by years of vigorous training and is maintained in the daily 'class'. Active stabilisation of the trunk ('core stability') is especially important: only if the body-centre is stable can the extremities move freely and independently. Dancing requires flexibility and strength. To perform the positions of '*attitude*' (Fig. 1) or '*arabesque*' (Fig. 5), a strong and flexible back is indispensable. For '*demi-plié*' (Fig. 2) maximal dorsiflexion of the ankle joint is required, the opposite, maximal plantar flexion, is the case in dancing on '*pointe*' (Fig. 3). '*Relevé*' (Fig. 4) is unique for dance and important for all forms of dance. '*Relevé*' combines maximal plantarflexion in the ankle and 90° of dorsiflexion in the first metatarso-phalangeal joint (MTP1) and is needed for balance during turns ('*pirouettes*') and take-off in jumps ('*sauté*'). The five classical ballet positions require a turned-out ('en dehors') position of the feet from the hips down, preferably 180° (Fig. 2).

Figure 2 Demi-plié (in first ballet position)

Figure 3 On 'pointe' in fifth position. These special pointe-shoes allow dancing on the tips of the toes

Causes of injuries in dancers

Injuries are caused by bad luck, fatigue, and stress, but, most of all, by faulty technique, the improper execution of classical ballet-technique, the basis of almost every dance training. Faulty technique in dance often is due to an ignorant compensation for physical limitations, which form a structural predisposition for dance injuries. The dance teacher is the first line of defence in the prevention of dancers' injuries. It is worth while mentioning separately 'growing pains' in young dancers: during the growth spurt bones grow faster than muscles. Growth ends first in the feet and the last body part to grow is the back. Growing pains tend to follow the same pattern. Polyarticular muscles (which span more than one growth plate, like m.rectus femoris, m.sartorius, and the hamstrings), temporarily become 'too short' and hence are especially more vulnerable for growing pains. Due to this stiffness and discomfort, the dance student is temporarily unable to fully lift the legs or make high kicks. In the worst case, the student is criticised and judged to be lazy by the teacher, starts forcing, develops complaints and gets injured.

Not every dancer has sufficient external rotation in the hips and inadvertently three types of compensatory mechanisms are used to mimic a better 'turn-out':

1. Lower back - lumbar (hyper-)lordosis results in hip flexion with relaxation of the anterior hip capsule (iliofemoral or Y-ligament),
2. Knees - an extended knee is rigid, but bending the knees allows external rotation of the lower leg,
3. Feet - hyperpronation ('rolling-in') gives the impression of additional turn-out by abduction of the forefeet.

Figure 4 Relevé: maximal plantarflexion in the ankle and 90° of dorsiflexion in the MTP1 joint

Once the desired turned-out position of the feet is achieved, the dancer 'grasps' the floor and 'stretches up' resulting in low back tension, exotorsion torque on the knees and stress on the medial side of the feet. This is an important source of dance injuries, which more often occur in dancers with a limited or asymmetrical

turn-out. It comes as no surprise that 77 % of orthopaedic dance injuries concern the lower extremity. Dancers are used to discomfort, but, because of their body awareness and due to their high physical demands, a pending injury is noticed in an early stage, often before modern imaging technology shows abnormalities.
A detailed patient history and thorough physical examination, including dance specific tests, are mandatory to reveal the diagnosis.

General principles of treatment

The first question an injured dancer asks is: 'How long am I out?'. Dancers are motivated to dance, but also to recover. Since they know their body well, time given to extensive explanation is well spent. Never give a dancer the advice to stop dancing, but if needed, the prescription of relative rest will be appreciated: only the use of the injured body part or the painful movement is to be avoided. Dance-specific rehabilitation with graded activity may imply that during 'class' the dancer participates only in the section called 'barre' and not in the exercises in the middle ('au milieu') or the jumps. To keep the body fit an injured dancer may exercise on the ground ('floor-barre'), avoid relevé ('flat-foot-barre') or train in a pool ('pool-barre'). Anti-inflammatory drugs, like NSAIDs, are used sparsely, because they mask the pain-warning-signal, leading to overexertion. Occasionally there is an indication for cortisone injections or operation. In every dance-injury, 'mental practice' ('visualisation') is the cornerstone for the maintenance of dance technical capabilities during rehabilitation and recovery. It makes sense to watch a dance class or a dance video.

Take-home messages (dancers)

- Compensation of insufficient external rotation of the hips is the most important source of dance-injuries.
- Never give an injured dancer the advice to stop dancing.
- 'Visualisation' helps to maintain dance technical capabilities.

Specific orthopaedic dance medicine

The (lower) back:

Aspecific low back pain is common in dance but rarely results in a referral to an orthopaedic surgeon, because it is often treated successfully by physio-manual-therapists and responds well to 'core-stability' training. Of course any specific causes of low back pain must be excluded:

Stress fracture of the vertebral arch, spondylolysis, gives pain on rotatory extension, like in 'arabesque' (Fig. 5) or 'attitude' (Fig. 1). Unilaterally, painful arabesque in adolescence is a stress

fracture until proven otherwise. Diagnosis is confirmed by plain radiographs and a bone scan. Hyperactivity on the bone scan in a recent injury requires immobilisation in a Boston-overlap brace.

Piriformis syndrome is especially common in dancers with a limited turn-out. The sciatic nerve is squeezed by the muscle belly of the piriformis, one of the short external rotators of the hip. Although it can be caused by a direct trauma to the buttock, it usually is a stress-related injury. Sitting tends to be painful, often with shooting pains to the lateral side of the knee. The diagnosis is established by typical, local tenderness deep in the m.glutaeus maximus, combined with specific stretch and resistance tests. The most important differential diagnosis is a radicular syndrome, which tends to be hard to diagnose in hypermobile individuals. Treatment is conservative with explanation of the condition and specific stretches.

In '*Kissing spines*', the lumbar spinal processes touch in hyperlordosis, one of the compensatory mechanisms in insufficient turn-out. It may also be caused by insufficient active stabilisation of a hypermobile lumbar spine combined with hyperkyphosis of the thoracic spine (caveat: scoliosis, osteochondrosis, Scheuermann's disease). Treatment is conservative with explanation and 'core stability'-strengthening exercises.

Figure. 5 Arabesque: straight knee (Natasja Lucassen, Het Nationale Ballet)

Scoliosis in female dancers is quite common, due to the fact that these girls are often advised to start ballet to improve their posture. In idiopathic thoracic torsion scoliosis, arabesque (Fig. 5) and attitude (Fig. 1) are easier when lifting the (usually left) leg at the concavity of the scoliosis.

The hip

The hip is the source of many dance-injuries, but injuries to the hip itself are relatively rare (10 % of all dance injuries). In every dancer–patient hip rotation should be measured prone. Limited or asymmetric external rotation of the hips is a risk-factor. Treatment of many hip complaints in

dancers is a combination of explanation, relative rest (avoid painprovocation, limit turn-out, less 'high legs') and specific strengthening. Injections or surgery are rarely needed.

Sartorius enthesopathy Overuse of the m.sartorius is common in dancers, especially during growth spurt, because it is an important hip flexor in the turned-out position.
Lifting the turned-out leg is typically painful, whereas lifting in neutral or turned-in position is pain free. There is local tenderness at its origin at the anterior superior iliac spine.

Snapping hip is common in growth. There are two types: lateral and anterior. In lateral snapping hip the major trochanter 'catches' the ilio-tibial tract in rotatory movements. It is pain-free, unless there is a trochanteric bursitis. The innocence of the condition should be explained and, if applicable, a leg-length discrepancy corrected. In anterior snapping hip, the tendon of the iliopsoas muscle glides over the anterior capsule of the hip in movements to the side ('*developpé à la seconde*'). It sometimes causes an iliopectineal bursitis.

Anterior hip pain is a difficult and varied problem in dancers. Local abnormalities must be excluded by physical examination and imaging. In *femoro-acetabular impingement (FAI)* and labral pathology specific provocation, like the 'flexion–adduction– internal rotation' test, is painful. Diagnostic intra-articular bupivacain injections in the hip joint and MRI arthrography help to establish the diagnosis. Arthroscopic labral surgery in dancers is still experimental.

The knee

Knee injuries, especially of the patello-femoral joint, are the second most common (25 % of all injuries) in dancers. One of the causes is the turned-out position. The knee externally rotates in flexion, but not in extension. Usually, dancers are unaware of the fact that they use this phenomenon to compensate for insufficient turn-out in the hips: starting from 'demiplié' (Fig. 2), hyperpronation and maximal external rotation, the feet are fixed to the floor and the knees are extended. The resulting torque on the knees leads to rotatory malalignment of the patello-femoral joint and tension of the medial structures. This is called 'screwing your knees' (Fig. 6) and may cause patello-femoral pain syndrome, retro-patellar chondropathy, medial meniscus tears, and (always lateral) patellar dislocation. Dancers must understand how these complaints may be prevented or treated by correct turn-out technique, strengthening exercises of the feet and inlays (arch supports) in the daily life (street-)shoes. After the acute phase and sufficient immobilisation, patellar dislocation is no contra-indication to continue dancing, provided a good 'placement' is used.

The ankle

Ankle injuries are the most common (27 % of all injuries) in dancers. This is due to the mandatory extreme plantar and dorsi-flexion (Figs. 2, 3 and 4).

'Dancer's heel' (posterior ankle impingement syndrome) is soft-tissue or bony impingement at the back of the ankle due to 'inflamed' capsule behind the talus, an accessory ossicle ('os trigonum'; Fig. 7a), or an enlarged posterior process of the talus ('Stieda's process'). An os trigonum is either a fractured (traumatic: 'Shepherd's fracture') or a non-fused (congenital) posterior process of the talus. It is present in 5-7 % of the general population, in 50 % bilaterally. It gives complaints only in extreme plantar flexion of the ankle-joint. Typical posterolateral ankle pain can be elicited by forced passive plantar flexion, especially with a wringing motion ('ankle-McMurray'). Diagnostics include plain lateral foot-radiographs, preferably in *relevé*. (On standard lateral ankle radiographs, traditionally made in 30° of internal rotation to compensate for the exorotation position of the malleoli, an os trigonum or enlarged posterior process is hidden behind the postero-medial side of the talus). Conservative treatment includes correction of placement without 'rolling-in' and sometimes inlays in the street shoes. If complaints persist, there is a place for cortisone injections in soft-tissue impingement. In bony impingement operative removal of the bony fragment is indicated (Fig. 7b).

'Dancer's tendinitis', tenovaginitis of the m.flexor hallucis longus (FHL) behind the medial malleolus is the most common ankle-injury in dancers. Often it coincides with bony posterior ankle impingement: the bony fragment leaves too little space for the FHL-muscle belly, which is caught in the entrance of its own tendon-sheath ('cork in bottle'-phenomenon), especially if there is a farreaching insertion of the FHL-muscle-belly. Dancers' tendinitis can present as a 'trigger toe', due to a nodule in the FHL tendon, the hallux makes a 'snap', jumping back from maximal plantar-flexion to neutral. The dancer complains of postero-medial ankle pain during plié. The diagnosis is based on clinical findings: typical local tenderness over the entrance of the FHL tunnel, directly behind the sustentaculum tali. Plain radiographs are made to exclude an os trigonum. If specific stretching of the FHL and optimising dance-technique is insufficient to cure the injury, then an operation is indicated: the tendon-sheath is released and, if present and symptomatic, an os trigonum is removed.

Anterior ankle impingement Particularly in cavus feet repeated microtrauma in landing from jumps may cause osteophyte-formation intra-articularly, at the front of the distal tibia and/or on the nose of the talus, resulting in a painful and limited demi-plié (Fig. 2). If a simple heel raise during dance is insufficient, arthroscopic anterior clean-out is the treatment of choice.

The foot

The foot is the dancers' instrument. A square foot with equal length of the first and second ray is the best foot-shape for dance. Floppy flatfeet and feet with unequal metatarsal length are a risk-factor for metatarsalgia, stress fractures of the second metatarsal (proximally!) and hammer toes. Since dancers need 90° of dorsiflexion for relevé (Fig. 4), any type of hallux rigidus (juvenile, degenerative or iatrogenic) is detrimental for a dancer and may mean the end of a dancing career.

Hallux valgus Medial foot pain is common in dancers due to hyperpronation and 'grasping' the floor when compensating for insufficient turn-out of the hips. This gives tension on the medial side of the feet and pronation-valgus stress on the hallux. In the case of familiar predisposition, this may aggravate hallux valgus in dancers with poor turn-out. Although an operation may be tempting for cosmetic reasons, one has to realise that every hallux valgus operation gives some loss of dorsiflexion in the MTP-1 joint (iatrogenic hallux rigidus). Hence, the rule of thumb is that operative treatment for hallux valgus in active dancers and dance teachers should be avoided.

Juvenile hallux rigidus A relatively stiff big toe with pain on dorsiflexion may occur in young dancers, often in adolescence. Occasionally there is a history of direct trauma. The MTP1 joint

Figure 6a: Side view of a dancer in correct second position demiplié: 'turn-out' from the hips down; the middle of the patella is centred over the second toe and no 'rolling-in' of the feet.
Figure 6b: 'Screwing your knees': side view of the same dancer in incorrect second position demiplié. The malalignment of the patellofemoral joint and the hyperpronation of the feet are clearly visible

Figure 7: Posterior ankle impingement.
a Os trigonum behind the talus.
b Same ankle fter removal of the os trigonum (plain radiographs on 'pointe': the nails in the soles of the pointe-shoes are clearly visible)

shows no degenerative changes. If conservative treatment fails, an extending closed wedge-osteotomy of the base phalanx can solve the problem.

Degenerative hallux rigidus A painful loss of dorsiflexion of the hallux in older dancers and dance-teachers usually is caused by 'abutment' due to a dorsal osteophyte ('cheilos': Greek=lip) on the head of the first metatarsal in MTP-1 osteoarthritis. It is a career threatening condition. A metatarsal bar in street shoes may help, but is impossible in most dancing shoes; besides, many modern dancers dance on bare feet. A 'Mann-cheilectomy', in which the dorsal one third of the head of the first metatarsal, including the 'exostosis', is removed, may give relief, if done on proper indication and with postoperative continuous passive movement (CPM) treatment.

'Sesamoïditis' Pain in the sesamoid bones under the head of the first metatarsal is common in dancers. Usually it is hard to distinguish between a (stress-)fracture, avascular necrosis or insertion-tendinopathy of the m.flexor hallucis brevis. Treatment preferably is conservative with relative rest and inlays, but the prognosis is long, uncertain and often unsatisfactory. In persistent cases sesamoidectomy may be performed, albeit without scientific evidence for the outcome in dancers. The finding of a split sesamoid ('bipartita') usually is coincidental, asymptomatic and not posttraumatic.

Take-home messages (dancers)

- Unilaterally painful arabesque is a spondylolysis/stress fracture of the vertebral arch until proven otherwise.
- Posterior ankle impingement, with or without tenovaginitis of the m.flexor hallucis longus is the most common dancers' injury.
- The rule of thumb is to not operate on a hallux valgus in an active dancer or dance-teacher.

MUSICIANS' INJURIES

General principles of orthopaedic musicians' medicine

Introduction

The Netherlands has 13,000 professional musicians, including teachers, and 5,000 vocational students, not including the professional choirs and 70,000 pop-groups. There are approximately 1,600,000 amateur musicians. In over 60 % of professional musicians the musculo-skeletal system is injured to the extent that performing is impossible for some time. Acute injuries directly caused by making music are rare. The vast majority of musicians' injuries is caused by an imbalance between load and load-bearing capacity, by too much (overuse), or in the wrong way (misuse), music making.

Causes of injuries in musicians

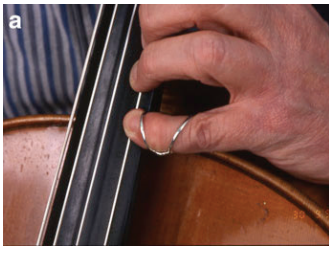
The main reason for 'overuse - injuries' is that the body(-part) is insufficiently trained for the required task. Apart from a wrong (sitting-)posture musicians' injuries are caused by a sudden change in the 'musical load' or the intensity of playing. In the patient history this aspect should always be checked. Possible sources can be a change of teacher, instrument, repertoire or practicing habits. Beware of a sudden change after a vacation or in preparation for a concert, audition or examination, or speedexercises with the metronome. Each change in 'musical load' is a risk-factor and has to be approached intelligently, gradually, with patience and sufficient time for rest and recovery. The turnover rate of collagen tissue (tendons, ligaments, connective tissue) is 300–500 days. The adaptational capabilities of the human body are immense, but adequate adaptation to major changes can take over a year. During this process it is wise to be alert for signals of overuse. The main signal is pain. Unfortunately pain usually comes after the activity or remains unnoticed due to the enthusiasm of the moment, so supervision by an experienced, responsible teacher is indispensable.
Physical limitations, like too little or too much flexibility, or (too) small hands, form a structural predisposition for injuries. Hypermobility in musicians is both an asset and a risk-factor.
General and specific physical fitness determine the loadbearing capacity or dynamic predisposition

for injuries and should be optimal in musicians, just as in top-sports. General overuse of the upper extremity can occur in a variety of demanding activities with muscle tension in daily life, like gardening, sports, work-out in the gym, lifting (anything from instrument cases, amplifiers and other technical equipment to young children). These should be avoided particularly immediately preceding music making, in which relaxed muscle use is desirable. Physical examination may reveal painful contractures especially in the lower arms and front of the shoulders.
Finally 'stress' also plays a role: stress gives muscle tension which in turn leads to injuries. Pain is usually the first warning signal. Pain means: stop playing, think and ask advice, if needed. A musician should not have pain and it is irresponsible to (try to) play through the pain. That may provoke a vicious circle with compensation, muscle tension, contracture formation and inflammation. Most injuries occur in violinists (30 %) and pianists (20 %). Bowed string-players and guitarists together form 53 % of the injured musicians. The upper extremity is affected in 78 % of the musicians' injuries.

General principles of treatment

Early specialised medical assessment (with the musical instrument) is essential to rule out specific injuries. The playing posture should always be checked. Operative treatment is rarely needed. There are three major groups of conservative treatment modalities:

1 Therapeutic conversation with extensive explanation and advice. Relative rest with frequent short breaks and sufficient recovery-time is the only effective treatment in overuse-injuries. During physical rest 'mental practice' is effective to maintain and augment musical capabilities. Other points of interest are: a healthy life-style, improvement of blood circulation and core-stability by general physical fitness training, muscle-care by warming-up, cooling-down and specific stretching exercises and, if applicable, completely stopping smoking.
2 Physical and posture therapy. These allied health therapies have a holistic approach and give special care to playing posture, stabilisation of the trunk and shoulder girdle and practising habits.
3 Other forms of conservative therapy: cortisone-injections and NSAIDs, immobilisation or stabilisation with tape, braces, splints (Fig. 8) or plaster of Paris; adaptation of the musical instrument, e.g. a (change of) shoulder support or chinrest on the violin, elongation of the c–c-sharp key and g–g-sharp key of a flute or a bent, 'ergonomic' flute, or an adapted thumb-rest for oboe or clarinet.



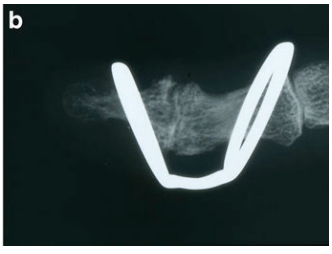


Figure 8 a 'Silver-ring splint' treatment in a 70-year-old celloplayer with osteoarthritis of the DIP joint of the left 5th finger with radial deviation. b Same patient, plain radiograph. The effect of the splint is according to the 3-point-principle, just like a correcting brace in medial osteoarthritis of a varus knee

Take-home messages (musicians)

- The most common causes of musicians' injuries are a (sudden) change in 'musical load' or a faulty playing posture.
- 'Mental practice' is effective inmaintaining and augmenting musical capabilities.

Specific orthopaedic musicians' medicine

Spine and neck

Posture-related cervicobrachialgia, myalgia of the m.trapezius descendens and (sub-clinical) thoracic outlet syndrome (TOS) Musicians tend to have increased antero-position of the head resulting in a hypertonic and painful (myalgia) m.trapezius descendens. This is not only due to insufficient physical fitness, but also to faulty muscle use ('mis-use') and bad posture with protraction and 'winging' of the shoulder blades ('scapula alata'). If the shoulder blades are not well stabilised, the m.pectoralis minor pulls the shoulder-blades up and forward, instead of acting as an accessory breathing muscle, pulling the chest up. At the start of a concert or in a difficult part, it is common practice to see musicians unconsciously lift their shoulders. This position results in entrapment of the brachial plexus and is the explanation for the high frequency of TOS, also known as costo-clavicular compression syndrome in musicians. On physical examination the Adson test may elicit the typical complaints (recognised by the musician patient), tapping on or around the collar-bone may provoke a positive Tinelphenomenon and the minor pectoral will be found to be hypertonic and painful on palpation. Treatment is conservative with extensive explanation, posture correction, stretch exercises of the front of the shoulder, strengthening of the shoulder-girdle and specialised physical therapy.

The shoulder

Impingement- (or painful arc-) syndrome of the rotator cuff (esp. m.supraspinatus) In playing of many musical instruments prolonged, static abduction of the upper-arm is required. This applies to the right shoulder in violin and flute playing. However in these two instruments the left shoulder is

adducted resulting in a 'wringing out'-phenomenon of the rotator-cuff: the poor blood supply of the 'critical zone' in the supraspinatus tendon is further impaired by the squeezing effect of this tendon being stretched over the head of the adducted humerus. Protraction of the scapulae causes or aggravates sub-acromial impingement. That is why musicians are prone to develop this condition; hence strengthening of the external rotators and stabilising the shouldergirdle deserves extra attention, both as treatment and as prevention. In resistant cases ergonomic adaptation of musical instruments, like the violin or the flute, may be necessary. Apart from this, the treatment of sub-acromial impingement is the same as in non-musicians.

Frozen shoulder: The cause of this condition remains uncertain. Although it easily may take up to over a year, usually the mobility returns with patience and reassurance. The physician must realise that even the slightest limitation of external rotation of the left shoulder, especially in the elevated position, makes violin, or viola playing impossible and/or leads to compensation, forcing, tension, and injuries in other parts of the upper extremity.

The elbow

Neuropathy of the ulnar nerve (ulnaropathy) in the 'cubital tunnel' at the elbow Ulnaropathy is surprisingly frequent in musicians (up to 9 % of all musicians' injuries). Several factors contribute to the entrapment of the ulnar nerve in musicians:

1 In many instruments, e.g. the left arm in cello, there is prolonged, significant flexion of the elbow, which stretches the ulnar nerve in the cubital tunnel.
2 At the same time the nerve is compressed by the two-headed origin of the m.flexor carpi ulnaris (FCU). This muscle stabilises the pisiform bone during abduction of the little finger. The FCU and the m.abductor digiti quinti both attach to the pisiform bone. Spreading and placing (flexion) the little finger in musicians is frequent, well controlled and powerful (e.g. the melody line in the right hand of the pianist or the left hand of the violinist or double-bass-player).
3 The ulnar nerve is used intensely in music making, because it innervates almost all intrinsic hand muscles.
4 Finally, in some musicians the ulnar nerve is subject to local pressure by the sound-box, as in double bass, harp, or guitar.

The musician complains of pain on the medial side of the elbow, sometimes with paresthesiae ('pins and needles' or a numb feeling) at the ulnar side of the hand. Physical examination reveals a positive Tinel phenomenon on tapping over the cubital tunnel and sometimes loss of strength of the intrinsics and diminished sensation. There may be a (sub-)luxation of the ulnar

nerve (congenital predisposition). Normal neurophysiological studies (electromyography, EMG) are no exception, but if the ulnar nerve conduction velocity (UNCV) is tested using the 'inching technique' (measuring the UNCV at 1-in. intervals), one may find a local 'latency jump' at the origin of the FCU.
As treatment a splint is provided to reduce flexion of the elbow during the night and, if possible, elbow-flexion is diminished during music making. Massage may have a place in suspected medial epicondylitis ('golfers' elbow') but is contra-indicated in ulnaropathy. Severe cases in which conservative treatment fails, may be treated operatively by a simple neurolysis, preferably combined with a subcutaneous anterior transposition if the musical instrument requires much flexion.

Supinator syndrome This entrapment of the deep motor branch (ramus profundus) of the radial nerve in the supinator muscle ('arcade of Frohse') is common in instrumentalists, like guitarists, violinists and violists, using their left arm in maximal supination. Complaints may mimic 'tennis elbow' but are felt more distally than the lateral epicondyle. Forced, resisted supination with an extended elbow is typically painful. The condition is also known as '(therapy) resistant tennis elbow' because the usual treatment for lateral epicondylitis fails: e.g. a compression bandage makes it worse. Treatment is explanation, specific stretching, and support of supination in daily activities. Operative neurolysis is indicated in the case of motor deficit (weakness of wrist, thumb, and/or finger extensors).

The wrist

After the shoulder, injuries to the wrist are the most common in musicians. A variety of injuries is encountered, like (insertion-)tendinopathies, carpal tunnel syndrome (CTS), De Quervain's disease, intersection syndrome, dorsal ganglion and 'carpal boss'.

Intersection syndrome ('drummers' wrist') This is a friction syndrome with pain at the intersection of the m.extensor carpi radialis (longus and brevis) and m.extensor pollicis brevis and m.abductor pollicis longus in the forearm. It is probably due to a combination of repetitive movements with simultaneous tension in both the wrist and thumb extensors. There is typical local tenderness at the intersection point and the 'Finckelstein test' (which is used for De Quervain's disease) is painful, but the pain is felt more proximally than the radial styloid process. Treatment is relative rest, specific stretching and cortisone injections. Operation is indicated in resistant cases and may reveal a tight band along the distal ulnar edge of the m.extensor pollicis brevis muscle belly.

Osteoarthritis of the first carpometacarpal joint (CMC1) is common in musicians and is treated with a simple thumb splint in activities of daily life. Depending on the instrument and the injured side, the splint may be used during music making: e.g. guitarists may wear the splint if the left wrist is injured, but not on the right side. If operation is unavoidable musicians in general need more mobility than strength. Hence a simple resection of the trapezium gives satisfying results in spite of slightly diminished grip strength.

The hand

Most hand injuries are not caused by music making, but may be extremely irksome in musicians. If music making is temporarily impossible, 'mental practice' should be done on a frequent, daily basis to maintain dexterity. The keys of rehabilitation are patience and graded activity with frequent short breaks, since the turn-over rate of connective tissue, especially in the hands, takes so long, up to over a year.

Stenosing tenovaginitis ('trigger fingers') and Dupuytren's disease require the standard treatment, although operation may be indicated in an earlier stage because of the higher demands on musicians' hands.

'Mallet finger' is a career threatening injury for musicians. Of course a bony avulsion has to be excluded with a plain, true lateral radiograph. The standard treatment with a plastic 'Stack' splint is insufficient. This immobilises the dip-joint unreliably and covers the so important pulp of the fingertip unnecessarily. A dorsal aluminium splint lacks these disadvantages, gives excellent results and allows for immediate music making.

Poly-osteoarthritis of the distal interphalangeal joints (DIP joints) is especially frustrating for retired active amateur musicians, who, after a busy working life, finally have the time to resume their beloved hobby. It is a familiar condition and not caused by music making. A stabilising, custom-made silver-ring splint during music making may serve as a good temporary solution (see figure 8).

Hypermobility: In hypermobile hands (e.g. 'locking swan-neck') silver-ring splints are also helpful for regaining control.

Primary focal dystonia (musicians' cramp, guitarists'cramp) is a task-specific, pain-free and, for the musician, an extremely serious disorder of control and coordination. A specific feature is the unconscious, uncontrolled and simultaneous contraction of local agonists and antagonists, e.g.

flexors and extensors of one or two fingers. This results in an abnormal position or movement of the affected finger(s) and total inability to perform at the desired, original professional level. For unknown reasons, it is very common in guitarists. The musician complains of a pain-free loss of control, occurring without obvious cause and only during music making without complaints in daily life activities. 'The finger is too slow and lacks control'. There is a similarity with 'writers' cramp'. Probably congenital in nature, the connections between individual flexor and/or extensor tendons are a hindrance and may play a role in its origin. These connections result in insufficient independency of the individual fingers and finally cause a central disorder of control. Making the diagnosis is easy, provided the physician is familiar with the condition and examines the patient during playing the musical instrument. So far there is no satisfying treatment. However, the fact that a proper objective diagnosis can be made provides a reassuring acknowledgement for the patient with this devastating injury, which has often been unjustifiably judged to be 'psychosomatic'.

CANS and RSI: The acronym CANS ('complaints of arms, neck and/or shoulders') was introduced in 2004 to replace the acronym RSI ('repetitive strain injury'). Although musicians make innumerable repetitive motions, this fact in itself does not cause an injury. In injured musicians it usually is possible to establish a classifying orthopaedic or neurological diagnosis. CANS is, just like RSI, not a diagnosis or a disease, but a descriptive expression, which may be useful in occupational medicine discussing work-environment

Take-home messages (musicians)

- If the shoulder blades are not stabilised sufficiently, the minor pectoral does not act as an accessory respiration muscle, but lifts and protracts the shoulders, leading to TOS and sub-acromial impingement.
- Ulnaropathy is surprisingly common in musicians
- Focal dystonia (musicians' cramp) is a task-specific and pain-free loss of control.

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Chapter 4a

Some thoughts on the prevention of complaints in musicians and dancers

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Some thoughts on the prevention of complaints in musicians and dancers

Abstract: This article summarizes the physical and psychological problems that can befall performing artists and aims to provide an insight into their prevention.

It is well accepted that prevention has three categories - primary (prior to any injury), secondary (preventing injury getting worse) and tertiary (learning from an injury for the future). But just what are we hoping to achieve; which complaints might benefit from prevention? The spectrum of medical disorders occurring in musicians is large [1, 2] and it behoves us to consider what we might be able to prevent. Table 1 is based on clinical experiences drawn from secondary and tertiary situations and shows the conditions that are probably preventable, as are some psychological disturbances.

Table 1	What can we (possibly) prevent?
	▪ Surmenage = overuse
	▪ Arthralgia = joint pain
	▪ Myalgia = muscle pain
	▪ Tendon irritation
	▪ Nerve entrapment

Prevention is probably of no relevance for other trauma, osteoarthritis or Dupuytren's contracture. *Prevention* was not a subject heading in Dawson's 2007 bibliographic review [3], but a year later, his book *Fit as a Fiddle* contains much preventive advice [4].
Prevention is in mind when choosing an instrument. Clearly, the age and size of the player are important when viewing the instrumentalist interface [5]. The weight of the instrument may play a role and there are various aids and adaptions which may help and hence prevent overuse or misuse (Table 2).

Table 2	Instrument adaptation
	▪ Neck cord; hip belt
	▪ Thumb rest support; key extensions
	▪ Thigh support
	▪ Angled cello pin
	▪ Harp stand
	▪ Reshape instrument

Sizing violins and violas for all ages can be summarized as follows: with the instrument in position, the instrument is too long if the hand (usually left) cannot hold the scroll comfortably with the elbow not fully stretched [6]. The next challenge for these players is an appropriate shoulder and chin rest combination [7-9]. The use of small size instruments for children is not restricted to string instruments. A lightweight plastic clarinet in C, a clarineo or an E-flat clarinet can be very helpful for beginners [10]. The development of the fagottino has grown apace, particularly in the Netherlands [11].

A case should be made for the better provision of pianos with a shorter keyboard span. In nearly all studies on the musculoskeletal complaints in musicians, the piano features prominently and the female gender is over-represented [2,12]. The small hands of Asian women are the subject of several reports and in correspondence with Japanese connections [13–16]. It is clear that the keyboard span was shorter in the period 1750–1850 when many famous pieces were composed [17]. The present-day instruments have a larger span and this may also contribute to the incidence of interosseous muscle pain, albeit in mainly female Japanese pianists [18]. Hand size may also be a factor in the complaints of female bassoonists [19]. The recent publication of a pragmatic hand evaluation may provide a better tool for investigating and reporting hand problems in musicians, and this in turn might lead to preventive advice [20].

The positive influences of the Feldenkrais method, Alexander technique and Mensendieck therapy only underline the need for attention to posture. The most common postural insufficiency in musicians is that the head and shoulders are too far forward. Shoulder complaints are common amongst musicians, particularly orchestral players [21, 22]. At the risk of sounding a bit glib, a simplistic approach to posture control is that the instrument should come to the player, not the player to the instrument.

Bad posture is not the only precipitating event in musicians' complaints. When asked, musicians often report such factors as excessive playing, a new teacher, a new technique, new (more difficult) repertoire or even a new instrument. It is worth taking a moment to note the physical effort involved in making music. Heart rates increase considerably during practice, rehearsal and concert; up to 79 % of the maximum theoretical heart rate [23] and the energy expenditure can rise by 32 % even when sitting [24]. In addition the respiratory rate, blood pressure and blood lactate concentrations rise as well as the perceived degree of exertion [25]. An obvious overlap with sporting activities exists [26, 27] and aerobic training has certainly helped a flautist tackle difficult repertoire [28]. The implication is that aerobic training would be beneficial for all musicians, as has been shown for dancers [29]. Although many complaints of the musculoskeletal system in dancers and musicians may be due to poor posture or faulty technique, it remains important to pay attention to the fact that some of these complaints, especially in children, may simply be due to other causes, like vitamin D deficiency [30].

By analogy with the above section on musicians, what can we expect to prevent in dancers? The spectrum of injuries in dancers is broad [30, 31], but focusing on injury prevention may obscure the aesthetic aspects. The aerobic training mentioned above [29] improved not only the proficiency in ballet dancers, but also their aesthetic standards. Aesthetic competence in contemporary dancers was also clearly related to specific physical fitness parameters such as push-ups and jump ability [32] as well as aerobic activity [33].
A reduced level of lower body muscular power was associated with increased severity of injuries in contemporary dancers [34]. Pain in university dancers could be reduced by prior training of calf, thigh and back muscles, particularly in those with a body mass index >21 kg/m^2 [35]. In an adolescent group of dancers, the risk of spraining an ankle was greater if the other side had ever been sprained, if hypermobility (increased passive inversion range) was present and if unable to balance on demi-pointe [36]; all this clearly pointing to insufficient muscle strength in the calf. In full-time ballet students, the type of body composition and percentage body fat (%BF) seemed a good predictor of injuries; ectomorphs with a low %BF had the highest injury rate [37]. From the world of sport medicine, we have learned that screening can be valuable in identifying problems. Potential disadvantages for a dancer are listed in Table 3.

Table 3	Potential disadvantages for a dancer
	▪ Stiff lower back
	▪ Limited exorotation of hip
	▪ Short Achilles tendon
	▪ Limited plantar flexion of ankle
	▪ Stiff big toe
	▪ Hyperpronation of feet

It is easy to attribute musicians' complaints to poor posture, an unsatisfactory instrument interface and inadequate physical training, but there are a number of external factors that should also be taken into consideration, e.g. seating, legibility of parts, appropriate spectacles, adequate light, hearing protection and ambient temperature can all influence discomfort. For the dancers, the ambient conditions are also important as well as the type of (sprung) floor [38], props and costumes. For both musicians and dancers, the rehearsal and performance schedules can be gruelling, let alone the travel required. The tips presented in Table 4 will help to alleviate some of these problems.

Table 4	Tips to help alleviate some of the complaints
	▪ Warming-up; general, then specific (i.e. with instrument or dance)
	▪ Stretching exercises; cooling down, massage
	▪ Rest day per week
	▪ Aerobic/cardio-fitness training
	▪ Recognize pain and overtraining symptoms
	▪ After period of rest/vacation/injury then gradual build-up of activity
	▪ Avoid heavy lifting before performing
	▪ Do not smoke

Performing artists have in common passion a dedication to their activity and a range of psychological problems. In the performing arts, emotion rules [39].Given the assumption that this reflects the artists' personality, their actions are characterized by emotion. This then means that there may be a tendency to behave more reactively than proactively, listening to the feelings of the moment rather than taking into account longterm effects. Looking from the perspective of executive functioning, there may be a resemblance to disorders such as ADHD (life long history of attention deficit and/or hyperactivity and/or impulsivity). In fact, research has shown a prevalence of ADHD symptoms in about 60 % of unselected female dancers presenting with somatic complaints [40]. Furthermore, the number of symptoms correlated with psychological problems. However, almost none of the patients reported these symptoms as being a problem for their work or social relations, underlining the importance of context in Diagnostic and Statistical Manual classification. Nevertheless, these traits may have an influence on a functional level, which could explain why, for example, most chronic physical disorders in musicians are caused by the lack of full rehabilitation [41]. Artists do not want to rehabilitate, they want to perform. This trait, a strength to perform at their best, is a weakness when it comes to pausing, to taking a day's rest each week and to rehabilitation. So, knowing what is good for you has little to do with doing what is good for you.
Hypermobility is common in dancers [42]. Having read the above, the chances are small that dancers will limit their turn-out during performance. Furthermore, although the aetiology is still unknown, we know now that hypermobility is linked to panic disorder [43]. So, there appears to be a link between the musculoskeletal state of the patient and a psychiatric disorder. Again, as the prevalence of hypermobility is above average in dancers, one can expect the prevalence of panic disorder within this group to be above average as well. Moreover, as several studies have stressed the link to agoraphobia as a more specific panic disorder, one should be aware of this when considering the high prevalence of stage anxiety in performing artists [44]. For a good review of music performance anxiety, see the articles by Bruquée [45, 46].

One important way of combining better and quicker medical progress during rehabilitation as well as satisfying the urge to perform is to use mental practice [47]. Patients with finger flexor tendon surgery of the hand had a quicker and better functional recovery if they practised extension and more specifically flexion in their mind while the finger was still immobilised [48]. During this period, the patient can also study new pieces or choreographies leading to a much more active role in rehabilitation, a quicker recovery and, often, an above average performance after the return to playing/dancing [49].

Probably, the most striking and disastrous effect of overuse is seen in task-specific focal dystonia (TFD). In this disorder, (small) muscles start to cramp, or lose their strength, during play, and (at first) only during play, leading to an inability to perform. No pain is involved, and other activities are unaffected. Nevertheless, this condition leads not infrequently to a definitive end of a career. As the consequences can be devastating, extra care should be directed to the differential diagnosis as well as to the mixture of factors leading to the inability to play. Most researchers stress a basal ganglia dysfunction as the aetiological background of the disorder although on many other levels contributing factors have been mentioned (e.g. spinal, peripheral, cerebellar, dysfunctional inter-tendinous connections) [50, 51]. Sometimes, the inability is caused by a technical problem or an anatomical limitation. For example, a flexor tendon of a finger can be too short to fully flex that finger if the wrist is already in flection. In this case, technical knowledge of the instrument, of the music that has to be played and of the functional anatomy of the hand can help lead to a quick and full 'recovery'. This example again stresses the importance of being skilled as a performing artist as well as being a doctor or psychologist when treating this patient group. In most cases, the motor complaints in TFD will lead to more practising which very often will lead to more complaints. This can be explained by the fact that in motor movement, motor systems depend for optimal functioning on sensory (mostly kinaesthetic/proprioceptive) systems. In other words, a disturbance in a sensory system will almost always lead to a dysfunction in motor functioning. The solution may thus lie in training sensory systems to restore motor functioning [52]. Last but not least, as this condition leads to much uncertainty in the patient, an additional effect will often be a classical conditioning hypersensitisation leading to extreme physical and psychological stress and worsening of symptoms when even thinking of the instrument let alone playing it [53]. Again, as symptoms can get worse through thinking, they also may get less through thinking and mental practice should always be considered as part of the rehabilitation process.

Preventing complaints in musicians and dancers is a challenge, but help is at hand. A sensible lifestyle helps, and various publications can provide support [4, 54–57].

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Chapters 4b

Dance-specific, graded rehabilitation: advice, principles and schedule for the general practitioner

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Dance-specific, Graded Rehabilitation: Advice, Principles, and Schedule for the General Practitioner

Abstract

Dancers frequently experience lower-extremity injuries which require dance activity restriction, if not full "time off" and/or surgery. Recovering dancers are frequently over-eager to return to dance, but engaging in too high an activity level too soon can be detrimental. Currently, there are no formal guidelines for general physicians about advising injured or postoperative dancer-patients about when or how to return to dance activity. Socioeconomic hurdles further prohibit many dancers from seeking rehabilitative services from a dance physical therapist. Therefore, there is a need for physician education about general dance-rehabilitation principles, as well as access to a dance-specific structured rehabilitation program. We present here rehabilitation advice from an expert in dance orthopedic surgery and an example of a "preventive rehabilitation program" for injured or postoperative dancer-patients with lowerextremity injury.

Introduction

To a dancer, the body is the artistic instrument, the creative product, and the crux of his or her person, passion, and profession. An injury can therefore be a profound crisis, as it threatens his or her career, livelihood, artistic expression, and the very embodiment of his or her identity. Among athletes, dancers sustain one of the highest rates of musculoskeletal injury from years of extensive training and performing. [1,2] Overuse injuries of the foot, ankle, and knee are particularly common, given the repetitive loading placed on largely unprotected or bare feet and often inappropriately sprung floors.[3–5] Most dancers, in fact, retire by age 30 due to premature physical deterioration or career-ending injury.[6,7] Nevertheless, dance medicine and particularly dance orthopedics remain small and largely unknown fields of medicine, with few guidelines for practitioners compared to their sports medicine counterparts.

Given this milieu, there has been a large push in the physical therapy literature for injury prevention among dancers[8]; however, many of the published schedules rely on supervision by a licensed physical therapist or Pilates instructor and the use of equipment.[9–11] Furthermore, the majority of dancers lack monetary resources, insurance, and access to general or dance-specific physical therapists and are faced with rehabilitating themselves back to dancing, even if being followed by a general physician or surgeon.[6,12] Among those dancers who do have access to professional rehabilitation, the gap remains between those exercises performed in the Pilates studio, clinic, or pool and those performed in routine dance class, such as dancing on one leg, turning, jumping, leaping, and dancing without assistance of the barre. While promising, "transition dance classes" are rarely offered in general dance studios.[13]

Therefore, there is a need for physician education about rehabilitation principles specific to injured dancers, especially for those physicians who are in the position of being the dancer's only source of advice about recovery and return to dance activity. For these physicians, access to a dance-specific rehabilitation schedule that is structured, self-executable, free, appropriate for many dance styles, and integrative into routine dance activity may be useful until formal guidelines are in place. To answer this need, we present our "preventive rehabilitation" advice and schedule, developed by the senior author who is a dance orthopedics specialist. (We define preventive rehabilitation as intelligent rehabilitation with gradual improvement and without major setbacks or reinjury.) These principles have been used for two decades in the recovery of, and prevention of reinjury in, dancers with lower-extremity injury.

General principles in dance rehabilitation

A beginning dancer does not start in an advanced class; likewise, an injured dancer cannot immediately return to his or her premorbid level. Dancers are frequently over-eager to return to dance, but engaging in too high an activity level too soon can result in reinjury. Rehabilitation

must occur in a logical progression from reacquisition of basic skills to finetuning of complex technique. Education about the warning signs of "over doing it" (i.e., the five cardinal signs of inflammation) is incumbent on the physician, as the dancer may not receive this education elsewhere. The following sequence is the backbone of rehabilitating dancers (and most athletes): focusing on mobility, then strength, endurance, and finally coordination/timing.[14,15] Mobility of the injured foot/ankle/knee often returns within 2 to 6 weeks postinjury/operation and is best judged by the orthopedic surgeon following the case. One exception to this rule is that maximal flexion of the knee following injury or surgery (e.g., arthroscopy) may take several months to 1 year to return until scar tissue has fully matured and stretched.[16]

"Graded activity" is the progression from non- to partial to full-weight-bearing exercises and then from no- to low- to high-impact exercises. In our experience, a few days after the injury/operation, the dancer is allowed to engage in non-weight- bearing "floor-barre" or Pilates exercises (pain permitting). This permits the dancer to work on core stability while supine and to keep uninjured body parts conditioned. When partial weight-bearing is allowed, the dancer can begin "poolbarre" (ballet barre in a swimming pool, with the body weight supported by buoyancy), if a pool is available. Otherwise, "floor-barre" and Pilates should be continued. If the dancer is postoperation, the wound must be healing well with sutures removed before entering the pool.

When full weight-bearing is allowed, as judged by the overseeing physician, the dancer may begin graded impact activities, starting with a no-impact "flat-foot barre" (ballet barre exercises without relevé, demi-pointe, turns, or jumps). During flat-foot barre, the dancer begins to reintegrate him or herself into normal dance technique, without the taxing efforts of gravity on the injured extremity. The dancer also may begin our formal dance-specific rehabilitation schema (described below), which slowly and methodically incorporates antigravity movements into the dancer's repertoire. The schedule further dictates how the dancer may advance in class (Table 1).

General cardiovascular exercises, such as low-impact cycling and walking, performed in addition to any rehabilitation schedule improve circulation and overall stamina. Though many professional dancers smoke, smoking cessation is even more critical during recovery. Healing scar tissue requires optimal blood circulation, and the associations between smoking, damaged microvasculature, impaired oxygenation, and increased injury/delayed healing are well supported in the literature.[17,18] Again, it is incumbent on the physician to discuss these issues with the patient.

Neuropsychological research suggests that mental practice is effective for recovering performing artists, as imagery and visualization of the desired outcome may help to restore

neuronal networks, maintain agility, and learn new repertoire without actually performing any movements.[19,20] If the recovering dancer can cope emotionally with not being able to participate fully, watching class or rehearsal is useful to this end. New research also suggests a high level of somatic, cognitive, depressive, anxious, and paranoid complaints among newly injured and recovering dancers.[21,22] Therefore, coping mechanisms, if not psychologic or psychiatric referral, need not be overlooked despite the fact that the primary complaint is orthopedic.

Dance-specific, graded, rehabilitation schedule

Once sufficient and pain-free mobility of the injured/ operated lower extremity has been restored and full weightbearing is allowed (as judged by a physician), we explain and administer the following dance-specific and graded rehabilitation schedule to dancers (Table 1, Figures 1–6). This schedule is broken into two phases of six steps each: relevé, or rise to full dorsiflexion of the metatarsophalangeal joints, and sauté, or small jumps. The full schedule takes 12 weeks to complete. Each step takes approximately 1 week, in which each exercise is done twice daily with 25 repetitions until all repetitions are performed easily. The schedule is modifiable for pain and weakness; the patient can go back to, or stay at, a lower step if he or she is too unsteady or uncomfortable to advance. Follow-up visits are scheduled within the rehabilitation period to monitor the injury and evaluate the dancer's experience.

The schedule progresses the dancer through graded impact exercises. In Phase 1 (no-impact), the dancer focuses on the relevé; jumps are not permissible at any point. Second position is preferred to promote equal weight-bearing on both feet. The overseeing physician should remind the dancer about proper alignment of the knee and ankle during plié, in order for the dancer to not force her turn-out, which results in "rolling in" (hyperpronation) of the feet and projection of the knees medially. Correct alignment involves tracking the center of the patella over the second metatarsal joint. "Rolling in" otherwise places valgus stress on the medial aspect of the knees, with lateralization of the patella and rotatory malalignment of the patellofemoral joint. This hyperpronation of the feet causes tibial torsion and is related to patellofemoral, pelvic, and lumbar complaints.[23,24] Corresponding class activities and instructions for return to pointework (if applicable) are listed in Table 1.

In Phase 2, the dancer returns to low-impact, small, controlled, and assisted jumps. If jumping is too painful or otherwise impossible, we advise the patient to return to Phase 1, step 6 (i.e., balancing). Alternatively, the dancer may repeat all of Phase 1 with an explosive relevé (rather than a "rollthrough" relevé) in preparation for jumping. At the end of Phase 2, unassisted jumps away from the barre ("petit allegro") are allowed. When petit allegro is comfortable, the dancer may progress to high-impact leaps ("grand allegro"). Eccentric muscle training, cardiovascular activities, and/or use of a trampoline may further help the dancer prepare for this final activity.

Table 1. Dance-specific, graded rehabilitation schedule

Phase 1: *Relevé*

Instructions: The dancer stands facing the ballet barre in a small second position in correct alignment and with weight evenly distributed on both legs.*
Without "rolling in," the dancer works through the foot from demi-plié to relevé and back, twice daily with 25 repetitions. Jumps are not permissible during Phase 1.

Step	Instructions	Class Activity
Step 1	With two hands on the barre, on two legs (Fig. 1 A–C)	Flat-foot barre. No-impact activities.
Step 2	With one hand on the barre, on two legs (Fig. 2 A,B)	
Step 3	Without assistance, on two legs (Fig. 3 A,B)	
Step 4	With two hands on the barre, on the operated/ injured leg (Fig. 4 A,B)	
Step 5	With one hand on the barre, on the operated/injured leg (Fig. 5 A,B)	Full barre activity.
Step 6	With one hand on the barre, balance on the operated/ injured leg after each repetition (Fig. 6 A,B)	Full barre. Easy "center-work," excluding jumps or turns.

Pointe work (if applicable): After completing phase 1 the dancer may resume pointe-work, provided sufficient plantar flexion is present within the foot and ankle, and the knee and lower leg are stabilized. The patient repeats Phase 1 rising to relevé on "full pointe."

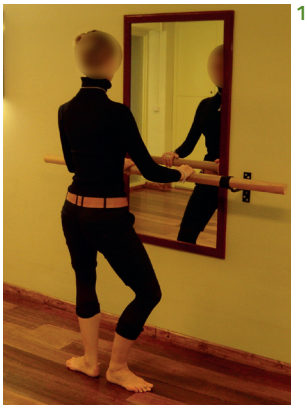
Phase 2: *Sauté*

Instructions: Once balancing on relevé on the injured leg is possible, the dancer may begin Phase 2. From the same starting position as Phase 1, the dancer proceeds explosively to a small jump at the barre, twice daily with 25 repetitions. If jumping is too painful, the dancer should repeat Phase 1 using an "explosive" relevé rather than a "roll-through" in preparation for Phase 2.

Step	Instructions	Class Activity
Step 1	With two hands on the barre, on two legs	Full barre, explosive relevé, center work without jumps. Low-impact activities.
Step 2	With one hand on the barre, on two legs	
Step 3	Without assistance, on two legs	
Step 4	With two hands on the barre, on the operated/injured side	
Step 5	With one hand on the barre, on the operated/injured leg	Full barre, center work. Small unassisted jumps, "petit allegro."

Pointe work (if applicable): After completing phase 1 the dancer may resume pointe-work, provided sufficient plantar flexion is present within the foot and ankle, and the knee and lower leg are stabilized. The patient repeats Phase 1 rising to relevé on "full pointe."

* Correct alignment during plié means tracking the center of the patella over the second metatarsal joint without "rolling in" (hyperpronation) of the feet.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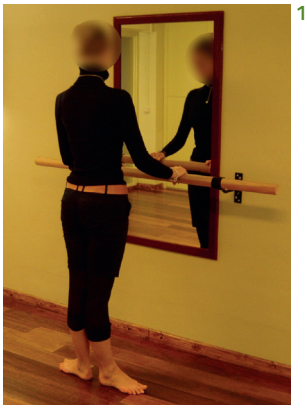
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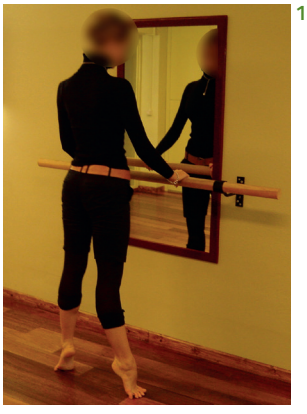
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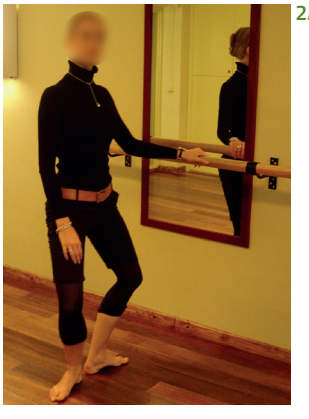
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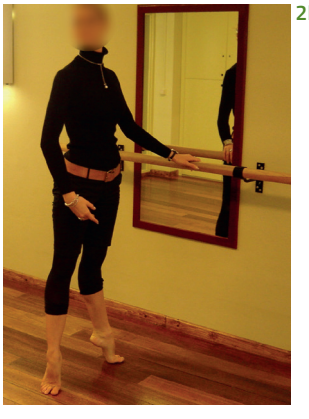
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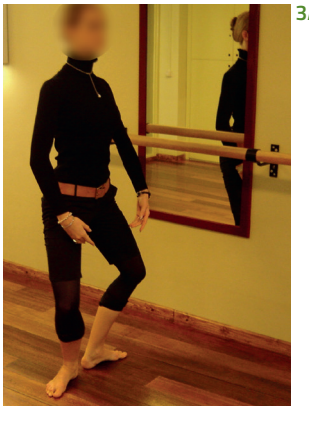
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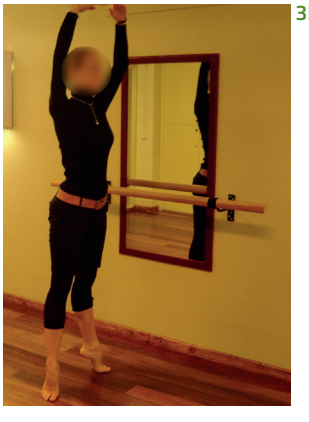
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Figure 1 A–C. Phase 1, Step 1: the "roll-through" relevé demonstrated in first position with correct alignment. Weight is evenly distributed over both feet. There is no hyperpronation or "rolling in" of the feet in the subtalar joints and no medial projection of the knees.

Figure 2 A, B. Phase 1, Step 2: partially assisted relevé.

Figure 3 A, B. Phase 1, Step 3: unassisted relevé.

(Photos used with permission of the dancer).

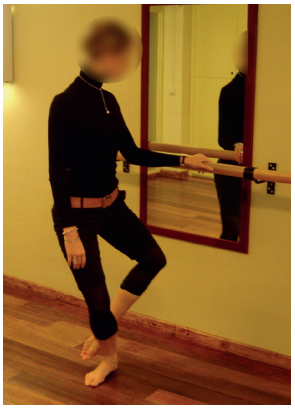
4A

4B

Figure 4 A, B. Phase 1, Step 4: unilateral work on the injured leg, with assistance. If the transition to Phase 2 (sauté or jumps) is too hard or painful, the dancers should repeat all steps of Phase 1, replacing the "roll-through" relevé with an explosive relevé.

Figure 5 A, B. Phase 1, Step 5: unilateral relevé with partial assistance.

Figure 6 A, B. Phase 1, Step 6: balancing exercise on the injured leg.



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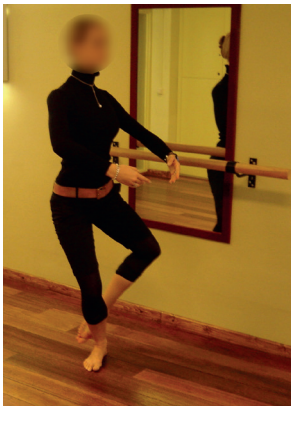

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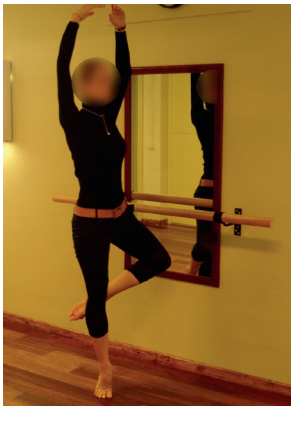

6B

Many dancers are also uncertain when to begin grand-plié, particularly after meniscus surgery. As it may take several months to 1 year to regain full flexion of the knee, we recommend that the dancer does not grand-plié any deeper than he or she is able to flex the knee in a non-weight-bearing situation. If the dancer has sufficient control, strength, and body awareness, he or she may begin grand-plié at any point during the rehabilitation schedule.

Discussion

Some physicians consider dancers to be ideal orthopaedic patients—given their drive to return to full activity after operation, level of preoperative physical fitness, and sense of body awareness.[25] However, dancers tend to be over-eager to return after injury and thus risk reinjury if rehabilitation does not occur in a stepwise, controlled fashion. Socioeconomic hurdles further hinder many dancers from obtaining physical therapy services in countries without nationalized health insurance. Given this environment, many dancers are faced with rehabilitating themselves. One frequent complaint in our clinic is that dancers have felt "lost" in the past about how to return to dancing after injury.

For these reasons, we developed the dance-specific, graded rehabilitation schedule presented here. The benefits of this particular routine are that it is self-executable, affordable, and integrative into regular dance class activities. The schedule is graded, progressing from no- to low- to high-impact exercises, but is also coordinated with activities in dance class. This is, in fact, what our patients value most about the schema, as we frequently hear "I knew how 'far to go' in class" with the program. Furthermore, the schedule does not necessitate supervision by a physical therapist, as the exercises are based on basic dance moves and require no equipment other than a railing. However, if the dancer has access to a rehabilitation specialist, the efforts can be synergistic.

This schedule is presented as neither a panacea nor standalone program. Cross-training with non-dance aerobic exercises, smoking cessation, proper nutrition, and (if applicable) psychological counseling are equally important in restoring the dancer to health. In the future, guidelines should be developed for general physicians regarding recovering the dancer back to full physical and artistic capability, and this schedule will need to be validated against others in order to be considered in those guidelines. However, in our experience this "preventive rehabilitation" schedule has been a useful and well-received check-and-training tool in our clinic for injured dancers for a structured and methodical return to the passion they love the most.

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Chapter 5

Hyperpronation in dancers: Incidence and relation to calcaneal angle

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Hyperpronation in dancers: Incidence and relation to calcaneal angle

Abstract

Hyperpronation is a common finding when examining the dancer-patient and is thought to be implicated in several dance-related injuries. Little is known about the incidence of hyperpronation-related symptoms in dancers. Additionally, there is no current easy method for estimating the degree of hyperpronation. This study was designed to investigate the incidence of symptoms related to foot hyperpronation in dancer-patients and to evaluate the potential correlation between the patient's calcaneal angle and severity of hyperpronation. A retrospective study of 2,427 dancers' charts over the past 6 years was undertaken to identify dancers who presented with musculoskeletal complaints or problems related to hyperpronation. Physical exam data and diagnoses were collected. Among 24 new dancer-patients presenting to clinic with hyperpronation-related symptoms, the calcaneal angle was measured and correlated with a clinical grading scale based on the Hübscher maneuver. Per chart review, the incidence of symptomatic hyperpronation resulting in prescription for orthotics was 30% (739 dancers out of 2,427). The most common related diagnosis was retropatellar chondropathy (10%). Clinical severity of hyperpronation was linearly related to the calcaneal angle (95% CI [1.25, 4.14], $p = 0.0006$; Pearson's $r2 = 0.97$). The calcaneal angles among mild, moderate, and severe hyperpronators differed significantly ($H = 13.45$, $p = 0.0012$). It was concluded that measuring the calcaneal angle may be a useful adjunct to the Hübscher maneuver for grading the clinical severity of a dancer's hyperpronation. Healthcare providers working with dancers should be aware of the presence of hyperpronation, its relation to compensatory turnout techniques, and association with injuries in the foot, ankle, knee, hip, and low back. A standard, time-efficient method of measuring and grading hyperpronation is still needed.

Introduction

Pronation of the foot is one of the planar movements made at the subtalar joint. It occurs during mid-stance of the normal gait cycle when the forefoot makes initial contact with the ground. This motion allows the foot to adapt to weight distribution, thus enabling shock absorption.[1,2] Excessive pronation, or hyperpronation, is thought to be a common foot problem, affecting about 20% of people worldwide[3]; however, the specific prevalence among dancers is unknown. The etiology of hyperpronation (often called "rolling in" when referring to dancers) is multifactorial. It can be the result of a compensatory mechanism seen in structural deformities[4] such as tibial varum and varus forefoot or rearfoot.[1,5] In dancers, it is thought to be a compensatory technique used to increase turnout—or a sequela of other compensatory techniques used to increase turnout[6] —when there is insufficient hip external rotation to achieve the classical ballet aesthetic.[1]

The compensatory turnout techniques have been well described elsewhere, [7] but will be briefly discussed here (Table 1).

A dancer commonly "sways" the lower back (into hyperlordosis) and then slightly flexes at the knees or subtly relaxes the knee extensors. This causes an anterior pelvic tilt and hip flexion, both of which relax the ilio-femoral (or Y-) ligament of the hip and allow for increased hip external rotation. This anatomical relationship explains why turnout is more easily achieved in ballet's second position or when the dancer is bending forward at the hips, as in a cambré. In a second strategy, while in demiplié, the dancer commonly rotates the feet outward, grips the floor with the toes, and then extends the knees, causing the feet to appear more turned out (see figure 1B). The knee joint allows for external rotation in flexion but not in extension, due to the screw-home mechanism of the femoral condyles.

Therefore, the dancer often needs to grip the floor with the toes to maintain the rotation with straight legs. Finally, the dancer's feet commonly "roll in" (i.e., hyperpronate) in an attempt to compensate for the torque on the knee from forced distal turnout (see figure 1B).

Table 1. Compensation for Lack of Sufficient Hip Turnout

Dancers use three compensatory mechanisms (often simultaneously) to force distal external rotation

1. The dancer *sways the lower back while slightly flexing at the knees*, causing anterior pelvic tilt and increased hip flexion.
2. The dancer forms a small demi plié and *externally rotates at the knees*. She then extends the legs fully, but must grip the toes on the floor to maintain the position (Fig. 1B).
3. The dancer *hyperpronates* at the foot to compensate for increased torque from forced external rotation at the ankles and knees (Fig. 1B).

Figure 1 Classical dancer performing a demi-plié: A. Correct alignment; B. Due to insufficient external rotation at the hip, this dancer incorrectly grips the floor with her toes and hyperpronates at the subtalar joint bilaterally.

Research suggests that total turnout is the combination of approximately 60° to 70° of external rotation at the hip and 10° to 35° from the remaining lower extremity.[7] Dancers who use compensatory strategies can achieve an average of 25.4° extra "functional" turnout, but more extreme compensation has been associated with significantly elevated self-reported injury rates.[6] At the ankle joint alone, excessive pronation stretches the supporting ligaments and tendons of the plantar and medial aspects of the foot and ankle, jeopardizing maintenance of the medial arch of the foot.[2] Excessive demands are then placed on the extrinsic muscles of the foot in an effort to stabilize the arch. This may predispose the tendons and their associated synovial sheaths and attachments to medial tibial stress syndrome, flexor hallucis longus tendonitis, or plantar fasciitis.[1,3,6] In dancers, hyperpronation may also lead to difficulty when resupinating the foot to go on pointe.[8] Hyperpronation has been implicated in the development of injuries further up the kinetic chain as well,[2,8,9] including patellofemoral pain syndrome (PFPS)

and retropatellar chondropathy (RPCP) from increased tibial torsion.[10] This tibial "rotatory malalignment" is thought to affect patellar tracking, which can result in injury over time.[4,11-13] Hyperpronation has been associated with an increased risk for non-contact anterior cruciate ligament (ACL) injuries,[14-16] (medial) sesamoiditis,[8,17] Achilles tendonitis,[1,8,17-19] leg length discrepancy,[13] stress fractures,[1] hallux valgus, and bunions.[2] Lastly, it has been associated with low back pain, in that internally rotating lower extremity forces predispose to flexion or abduction of the hips, anterior pelvic tilt, and increased lumbar lordosis.[5,20,21]

The incidence and prevalence of hyperpronation in dancers is unknown; however, for a multitude of reasons, it is thought that dancers may be predisposed to developing hyperpronation or symptoms caused by it. For one, dancers' feet are largely unsupported during dance activity. Many dance styles are performed barefoot, in slippers, or in "split-sole" shoes that lack arch support.[22] As mentioned previously, dancers are also frequently required to dance with extensive hip external rotation ("turnout"), regardless of their anatomical make-up.[1,17,23] Joint hypermobility may also play a role, as data suggest that hypermobile dancers may be valued during the training years but naturally selected out of the professional ranks due to injury.[24] Healthcare providers have achieved little consensus with regard to methods for assessing the severity of hyperpronation in the general patient population, much less among dancers or other athletes. Measurement of the calcaneal angle, representing calcaneal eversion in relation to the tibia, has been previously described as a relatively easy method of estimating the degree of hyperpronation[9,25-28] in comparison with tests such as the navicular drop test[7] or measuring dorsal arch height with the Sit-to- Stand test.[29] However, the association between calcaneal angle and clinical severity of hyperpronation (as assessed by the healthcare provider) has not been determined. A calcaneal angle less than 2° is thought to be consistent with no hyperpronation,[10] but grading systems of clinical severity do not exist for angles beyond that. In the dance population, even less is known about the relationship between physical exam techniques, measurements of hyperpronation, and functional outcomes in dancers who hyperpronate. Therefore, this study was designed to investigate the incidence of symptoms related to foot hyperpronation in dancer-patients and to evaluate the correlation between the calcaneal angle and the clinical severity of hyperpronation.

Materials and Methods

This study took place at the Medical Center for Dancers and Musicians (MCDM) in The Hague, The Netherlands, between July 2008 and January 2009. It was part of a larger study that examined the use and effectiveness of orthotics in dancers diagnosed with complaints related to hyperpronation. All study protocols and questionnaires were approved by the Medisch Ethische Toets Commissie ZuidWest Holland (METC ZWH). The study participants were

volunteers, who signed consent forms prior to participation. All questionnaires used were available in both Dutch and English.

Chart Review: At the time of chart review, the readily available (last six years) archive of the MCDM patient data filing system contained a total of 2,427 different dancers' charts. These were all non-selectively and alphabetically explored to identify patients who had presented with complaints related to hyperpronation of the feet and been prescribed orthotics. All of the dancers had been seen and diagnosed by the same physician over this time frame. The dancers selected for study had to meet the following inclusion criteria: an injury or chief symptom thought to be related to foot hyperpronation, and receipt of a prescription from the senior author for custom-made orthotics. Also, the specialty dance medicine clinic's referral policy requires that patients must be dancing a baseline minimum of 3 hours per week when uninjured in order to be seen. After screening for inclusion criteria eligibility, patients' charts were de-identified, and data were collected regarding the chief complaint, history of present symptoms, and results of the physical exam, including the degree of hyperpronation of one or both feet.

Calcaneal Angle and Clinical Severity: To investigate the relationship between the calcaneal angle and the severity of hyperpronation, dancer-patients who were seen at the clinic during the study period and prescribed orthotics for symptoms related to hyperpronation, were asked

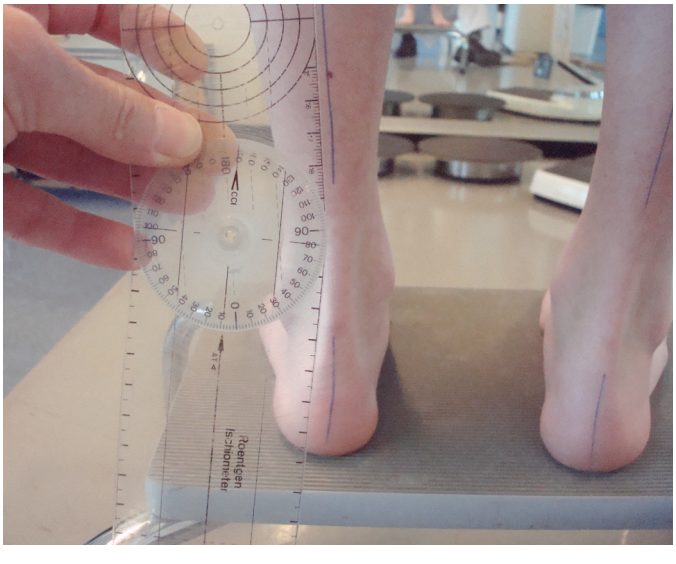

Figure 2 Measuring the calcaneal angle using a goniometer.

for consent to have the first investigator take measurements of the calcaneal angle at the time of their visit. These dancers had to meet the inclusion criteria listed above for the dancers in the chart review. Those who were found on physical exam to have hyperpronation that was not thought to be related to the complaints were excluded. All dance styles, ages, and both genders were included. All patients seen during the study period were examined and diagnosed by the same physician (the senior investigator), who is a performing arts medicine orthopaedic surgeon and director of the MCDM. Therefore, the exam technique and level of dance medicine expertise were constants across all patients in the study. The measurement of the calcaneal angle and examination by the senior physician occurred independently of one another.

Estimating the Clinical Severity of Hyperpronation: The degree of hyperpronation was graded based on a scale that the senior author has used clinically for the last 20+ years. In this portion of the physical exam, the physician was seated in front of the standing barefoot patient. The physician observed "rolling in" of the feet and the valgus position of the ankle with the dancer in a relaxed stance after maximal inversion and eversion of the ankles. Then, the hallux was extended (dorsiflexed) at the MTP joint while the other digits remained on the floor. This maneuver, known as the Hübscher maneuver or Jack test,[30] causes eversion of the foot back to neutral positioning. The visual estimation of the amount of "rolling in" with the dancer at rest, plus the amount of correction needed to obtain neutral position during the Hübscher maneuver, were used to grade the severity of hyperpronation, from + to +++ (mild to severe). Each foot was examined separately. Thus, a patient with chart score of +/++ had a right foot with a mild degree of hyperpronation and a left foot with moderate hyperpronation.
Although each foot was examined separately, for the purposes of this study the participant was classified as being an overall mild, moderate, or severe hyperpronator based on the more severe foot.

Measuring the Calcaneal Angle: The calcaneal angle represents calcaneal eversion in relation to the tibia.[10] It is calculated as the angle between a line bisecting the calcaneus, and a line bisecting the lower leg. In this study, to make the measurement more precise, the two lines bisecting the lower leg and the calcaneus were drawn on the patient by the investigator with a blue pen. The calcaneal angle was then measured using a goniometer (Fig. 2). The patient was positioned in a relaxed stance on a 20 cm high footstep with both feet and lower legs exposed. The investigator was positioned behind the patient such that the lower one-third of the lower leg was at eye-level.The upper half of the goniometer was aligned with the lower third of the calf, the lower half with the calcaneus, and the angle formed by the calcaneal eversion was read and recorded. The same goniometer was used for all measurements.

Statistical Analysis: Statistical analysis was performed using SPSS (version 17.0) statistical software (Chicago, Illinois, USA). To investigate the differences in calcaneal angles between the different hyperpronation groups separately (for example, between mild and severe hyperpronators), the Student's t-test was used. To compare the three hyperpronation groups for the difference in calcaneal angle, a one-way ANOVA was used. To investigate the relation between the calcaneal angle and the degree of hyperpronation, the X^2 test and the Pearson correlation were used. In the analyses, each foot was treated as an individual subject. The level of significance was set at $p < 0.05$.

Results Chart Review

Study Participants: In the chart review, 737 of 2427 patients met the inclusion criteria (30%). A total of 24 patients (2 males, 22 females; mean age: 25.0 ± 15 years; range: 10 to 68 years) agreed to participate in measuring their calcaneal angle at the time of their visit. Demographic data are displayed in Table 2.

Table 2. Demographic Data of Study Participants in the Chart Review

Variable	Study Group Chart Review (N = 737)	Study Group Calcaneal Angle (N = 24)
Age at consult MCDM, M (SD)	25.3 (12.0)	24.8 (15.0)
Female, n (%)	614 (83.3)	22 (91.7)
Male, n (%)	123 (16.7)	2 (8.3)
Degree of hyperpronation, n (%)		
Mild (+)	186 (25.2)	6 (25)
Moderate (++)	138 (18.7)	15 (62.5)
Severe (+++)	43 (5.8)	3 (12.5)
Level of dancer, n (%)		
Professional	199 (27.0)	1 (4.2)
Teacher	13 (1.8)	2 (8.3)
Student	316 (42.9)	10 (41.7)
Amateur	203 (27.5)	11 (45.8)

Incidence and Severity of Hyperpronation: Based on chart review, symptomatic hyperpronation occurred in 30% (N = 737) of dancers seeking treatment at the MCDM over the last 6 years. Of these 737 charts, the degree of hyperpronation was recorded in 371 charts (50.3%). According to the classification system described in the Methods section, 50.7% (N = 188) of patients were classified as mild (+), 37.2% (N = 138) as moderate (++), and 12.1% (N = 45) as severe

(+++) hyperpronators. In 77 dancers (21.0%), the right and left feet displayed asymmetric hyperpronation. There was no significant difference in the degree of hyperpronation between all right and left feet ($X^2 = 0.78$, $p = 0.85$).

Diagnoses Related to Hyperpronation: Per chart review, the most common diagnosis related to hyperpronation was retropatellar chondropathy (RPCP), found in 75 (10%) of the dancer-patients. This was followed by FHL-tendonitis in 56 dancers (6.7%) and lumbago in 47 dancers (6.4%): see Table 3. Among the "Other" diagnoses not mentioned in the Table were: piriformis syndrome, sesamoidalgia, and anterior impingement of the ankle. Approximately one-third of all conditions involved the knee.

Table 3. The Most Common Diagnoses among Dancers Presenting with Hyperpronation-Related Complaints

Diagnosis	N (%)
Retropatellar chondropathy	75 (10.2)
Lumbago	70 (9.5)
FHL-tendonitis	56 (7.6)
Apexitis patellae (Jumpers' knee)	31 (4.2)
Rotatory malalignment	30 (4.1)
Hallux valgus	27 (3.7)
Metatarsalgia	26 (3.5)
Nonspecific knee complaints	26 (3.5)
Shin splints	25 (3.4)
Patellofemoral syndrome	21 (2.9)
Posterior impingement ankle	21 (2.9)
Meniscopathy	19 (2.6)
Sinus tarsi syndrome	15 (2.0)
Nonspecific foot or ankle complaints	14 (1.9)
Other	281 (38.1)

Calcaneal Angle and Clinical Severity: The calcaneal angle was measured in 24 patients (48 feet). Among mildly (+) hyperpronated feet the mean calcaneal angle was 4.9° (± 1.9°, range 2° to 8°), in moderately (++) hyperpronated feet 7.5° (± 3.5°, range 2° to 16°), and in severely (+++) hyperpronated feet the mean calcaneal angle was 10.2° (± 3.0°, range 7° to 16°). The calcaneal angles among all mild, moderate, and severe hyperpronators differed significantly

(H = 13.45, p = 0.0012). The angles differed significantly between + and ++ hyperpronation (95% CI [-6.06, -0.87], p = 0.01), and between + and +++ hyperpronation groups (95% CI [-7.67, -2.95], p = 0.0002). There were no significant differences between ++ and +++ hyperpronation groups (95% CI [-4.95, 1.25], p = 0.23), (Fig. 3). There was a linear relationship between the calcaneal angle and degree of hyperpronation (95% CI [1.25, 4.14], p = 0.0006; Pearson's r2 = 0.97).

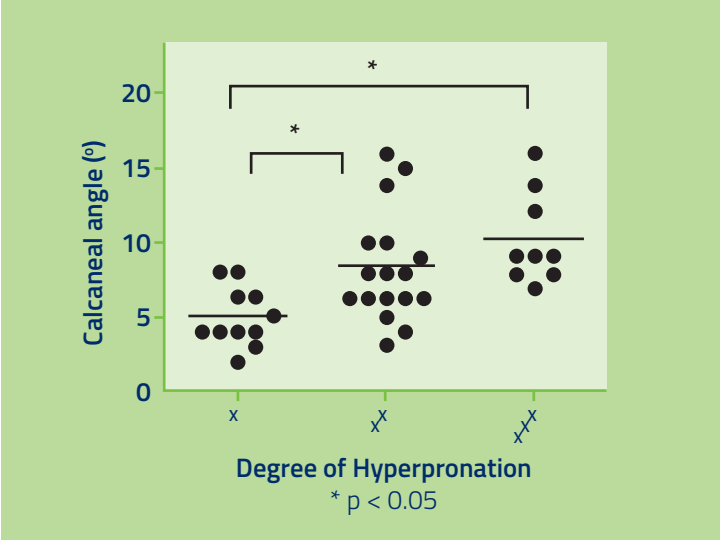

Figure 3 Calcaneal angle across degrees of hyperpronation. Three different degrees are shown: + (mild hyperpronation), ++ (moderate hyperpronation), and +++ (severe hyperpronation). There were statistically significant differences found between the mild and moderate degrees, and between the mild and severe degrees of hyperpronation ($p < 0.05$).

Discussion

Hyperpronation of the foot is a common physical exam finding and thought to be related to, if not causative of, certain somatic injuries. This is the first study to examine the incidence of hyperpronation in dancer-patients seen at a high-volume referral center for performing artists. It is also the first study to examine the correlation between the calcaneal angle and the clinical severity of hyperpronation. Results suggest that hyperpronation is a prevalent and important finding in dancers.

Based on the six-year chart review of 2,427 dancers seen at our performing arts medicine clinic, the investigators estimate the incidence of hyperpronation in dancers seeking treatment to be 30% (most were mildly hyperpronated). This incidence in dancers is higher than previously reported estimates of the general population (20%).[3] It is difficult to make reliable comparisons between studies, given that there are no guidelines for diagnosing or classifying hyperpronation. However, we believe that the role of hyperpronation in compensatory turnout

techniques, as well as the higher prevalence of hypermobility among dancers compared to the general population, may contribute to the higher incidence of symptomatic hyperpronation found in this study. We also recognize that the true prevalence of hyperpronation in dancers may be even higher, given that only dancers who had chief complaints thought related to hyperpronation (and thus prescribed orthotics) were included in the study. Incidentally found hyperpronation in dancers who had an unrelated complaint was not counted. Also, we only examined injured dancers presenting to clinic, rather than perform a screening exam of community non-patient dancers. Nevertheless, one of the strengths of this study's estimation was the large sample size of dancers available by chart review, which would otherwise be difficult to obtain in the community. There is currently no standardized way of measuring hyperpronation that also gauges clinical severity. Other classification methods such as applying the criteria of a navicular drop of >15 mm,[31] the presence of a medial talonavicular bulge,[32] a calcaneal eversion angle of >9.2° and a medial longitudinal arch of < 134.6°,33 likely select for the most severe cases of hyperpronation. Other methods for measuring hyperpronation are often time-consuming and not practical for a healthcare provider to apply in daily practice. In this study, the calcaneal angle correlated strongly with the clinician's judgement of hyperpronation severity (+, ++, +++). The technique for measuring calcaneal angle and for performing the Hübscher maneuver is a relatively simple and efficient method that can be done in minutes.

We recognize that clinical judgement is an important part of the global assessment of a patient's hyperpronation. The grading system used in this study, for example, is based on the experience of the attending physician. This judgement in part develops with time and experience; however, given the linear relationship between the calcaneal angle and the grading scale by Hübscher maneuver, healthcare providers may find goniometry to be useful when developing their clinical acumen. There were several limitations to this study. Most limiting was the small number of dancers available when investigating the relationship between the calcaneal angle and the degree of hyperpronation (N = 24). Another limitation is that the method of categorizing the study patients by severity of hyperpronation (+ to +++) was subjective. As mentioned, there is currently no standard among healthcare providers for physically examining or grading hyperpronation on a clinical scale, especially in the dancer-patient. The benefit of using the + through +++ system in this particular paper was that it has been used in clinical practice with thousands of dancer-patients by a physician who is extensively trained in the field of performing arts medicine. Furthermore, this methodology excluded inter-operator effect by using only one examiner.

Conclusion

The incidence of hyperpronation causing symptoms or musculoskeletal injury is common among dancers presenting to healthcare providers. Assessment of hyperpronation should be included in the physical exam of all dancers with foot, knee, hip, and back complaints. The calcaneal angle can be a useful adjunct to the Hübscher maneuver for grading hyperpronation. More research is needed to find the best physical examination tool that correlates with clinical severity of hyperpronation. Healthcare providers can play a unique role in educating dancers about hyperpronation as a risk factor for injury and encouraging avoidance of potentially injurious compensatory turnout techniques.

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Chapter 6

Use and Effectiveness of Orthotics in Hyperpronated dancers

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Use and Effectiveness of Orthotics in Hyperpronated dancers

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Abstract

Hyperpronation is a common foot problem in dancers. The aim of this study was to investigate the usage and effectiveness of orthotics in the management of symptomatic hyperpronation among dancers. A prospective cohort study of all dancer-patients in the investigators' practice who were prescribed orthotics for new symptoms related to hyperpronation between July 2008 and January 2009 was conducted. In this group, the longitudinal medial arch angle of the foot was measured by the Foot Build Registration System (FBRS), both barefoot and while wearing the orthotics. In addition, patients filled out questionnaires addressing perceived effectiveness of the orthotics for pain reduction and dance ability, among other items. A second retrospective study was conducted in order to obtain longitudinal data regarding dancers' compliance with, and subjective evaluation of, wearing orthotics over the preceding 6 years. Among participating dancers who met criteria for the prospective (N = 24) or retrospective (N = 81) aspects of the study (total N = 105), 67% wore orthotics at the time of follow-up. The average compliance in usage was 6.0 (± 1.5) days per week and 7.5 (± 3) hours per day. The average rate of satisfaction was 67.9 (± 26.5), average degree of relief in symptoms was 58.3 (± 28.3), and self-reported degree of improvement in dance ability was 45.7 (± 27.9) on a 100 mm Visual Analogue Scale (VAS). There was a significant decrease in pain from the day of orthotics prescription to follow-up (25.9%, or 18.9 mm decrease on the VAS, CI 6.6-30.9, p = 0.005) in the prospective group (N = 24). Orthotics were found to decrease the medial longitudinal arch angle significantly during static stance with the orthotic in place (CI 0.08-1.65, p = 0.03). It is concluded that the dancers in this study demonstrated a high rate of compliance in obtaining and wearing their orthotics and experienced a significant decrease in pain.

Introduction

Pronation of the foot is one of the triplanar movements made at the subtalar joint and occurs when initial contact is made by the forefoot with the ground, enabling shock absorption.[1,2] Excessive pronation, or hyperpronation, is thought to be a common foot problem; it affects about 20% of people worldwide[3] and is found in approximately 30% of dancers.[4] The etiology of hyperpronation (commonly called "rolling in" among dancers) is multifactorial. It is often the result of a compensatory mechanism seen in structural deformities[5] such as tibial varum and varus forefoot or valgus rearfoot.[1,6] In dancers, hyperpronation is thought to play a role in, and be exacerbated by, compensatory strategies to achieve the classical ballet "turned-out" (externally rotated) aesthetic when limited external rotation exists at the hips. A common pattern of compensation in dancers who "force" their turn out involves: 1. hyperlordosing the lumbar spine while slightly flexing at the knees, 2. internally rotating at the tibia while rotating the toes outward, resulting in hyperpronation at the subtalar joint and gripping of the floor with the toes to hold the position, and 3. hyperextending the knees (see figure 1).

Figure 1 Classical dancer performing a demi-plié: A. Correct alignment; B. Due to insufficient external rotation at the hip, this dancer incorrectly grips the floor with her toes and hyperpronates at the subtalar joint bilaterally.

It is unclear whether forced turn out during dance activity causes permanent hyperpronation over time in those previously without it, worsens pre-existing hyperpronation in individuals born with it, or whether hyperpronation remains situational to the dance activity. Nevertheless, it is implicated in altered lower extremity biomechanics at the distal foot, knee, hip, and pelvis,[1,2,7,8] which is thought to predispose to injury, particularly with repetitive tasks such as forced turn-out.[1,2,7,8-12] Hyperpronation has been associated with the development of conditions such as patellofemoral pain syndrome (PFPS), retropatellar chondropathy (RPCP),[6,13-16] flexor hallucis longus tendonitis,[7] Achilles tendonitis, [1,7,9,17,18] hallux valgus, and bunions, [2] all of which are among the most common injuries in dancers.[4,19] In addition, excessive pronation stretches the supporting ligaments and tendons of the plantar and medial aspects of the foot and ankle, which jeopardizes the maintenance of the medial arch.[2] Hyperpronation may also lead to difficulty during re-supination of the foot to go on pointe.[7] At the investigators' clinic when a dancer-patient presents with symptoms related to hyperpronation, orthotics are regularly prescribed for conservative management. These orthotics are rigid arch supports that span three-quarters of the length of the foot and are custom made by a trusted orthopaedic technologist who uses a non-weightbearing foam mold and a weightbearing blueprint (see figure 2). Most orthotics contain a metatarsal pad, unless the dancer is younger than 18 years of age. The orthotics are meant to be worn in street shoes only for relatively static activities (standing and walking) but not dynamic dance activity. There is currently no device that can fit into ballet slippers, soft shank jazz shoes, or pointe shoes to control hyperpronation while still allowing the dancer to have the fine mid- and forefoot articulation that is required for dancing. Orthotics have been shown to decrease tibial internal rotation,[20] the calcaneal eversion angle,[21,22] and navicular drop,[23] which are all associated with hyperpronation. They appear to reduce complaints in patients with PFPS[20,24-30] by reducing maximum pronation and calcaneal eversion and decreasing maximum internal tibial rotation acceleration and velocity.[31-33] Orthotics have additionally been shown to decrease the risk of developing overuse injuries such as medial tibial stress syndrome (MTSS) and stress fractures.[34,35] However, they are costly and time consuming to obtain (which may pose challenges to dancers, who are often limited by income), and it is unclear whether these benefits translate to the dancer-patient, who is unable to wear the orthotics during the very

Figure 2 Custom made three-quarter length rigid orthotic. This particular model includes a metatarsal pad.

Table 1. Demographic Data of Study Participants

Variable	Retrospective Group (N = 81)	Prospective Group (N = 24)
Age at consult MCDM, M (SD)	31.2 (12.9)	24.8 (15.0)
Female, N (%)	69 (85.2)	22 (91.7)
Male, N (%)	12 (14.8)	2 (8.3)
Degree of hyperpronation, N (%)		
▪ Mild (+)	26 (32.1)	6 (25)
▪ Moderate (++)	23 (28.4)	15 (62.5)
▪ Severe (+++)	8 (9.9)	3 (12.5)
▪ Unknown	24 (29.6)	0 (0)
Level of dancer, N (%)		
▪ Professional	28 (34.6)	1 (4.2)
▪ Teacher	5 (6.2)	2 (8.3)
▪ Student	28 (34.6)	10 (41.7)
▪ Amateur	20 (24.7)	11 (45.8)

activity in which hyperpronation is thought to be exacerbated.
Despite the widespread prescription of orthotics, there is no evidence regarding compliance with wear or effectiveness in dancers with symptoms related to hyperpronation. Therefore, the purposes of this study were to evaluate dancers' compliance with orthotics when prescribed for symptomatic hyperpronation and to investigate whether wearing rigid three-quarter orthotics during nondance activity reduces symptoms during dance activity.

Materials and Methods

This study took place at the Medical Centre for Dancers and Musicians (MCDM), The Hague, The Netherlands between July 2008 and January 2009. All study protocols and questionnaires were approved by the Medisch Ethische Toets Commissie Zuidwest Holland. The study participants were informed of the study protocol and provided written consent prior to participation, which

* It may be argued that 3 hours does not suffice for the definition of a "dancer"; however, this clinic treats dancers of all backgrounds, levels, and intensities. Three hours is used as a "cut off" to be seen in the clinic and is useful for capturing the spectrum of amateur dancers, former dancers who may have previously danced more hours, injured dancers who are currently not dancing to their fullest, as well as the range from academy students to professional dancers. This study was designed to be generalizable to the dancing patient population at large, rather than one specific or elite group. However, the investigators encourage further research into specific subgroups of dancers.

was voluntary. If requested, the participants received compensation for their travel costs. All questionnaires were available in Dutch and English.

Prospective Study

Dancer-patients who were seen at the MCDM during the study period and prescribed orthotics for symptoms related to hyperpronation, were invited to participate in the prospective study regarding compliance rate and effectiveness of orthotics. Dancers had to meet the following inclusion criteria: engagement in 3 or more hours of dance activity per week,* a chief complaint thought to be related to foot hyperpronation, and receipt of a prescription for custom made orthotics. Dancers who were found to have incidental hyperpronation on physical exam (that was not thought to be related to the chief complaint) were excluded. All dance styles and ages and both genders were included (Table 1). By the time of their formal entry into the study, all patients had been given a physical exam by the senior investigator, who is a performing arts medicine specialist. Eligible dancers were asked to fill out a five-item questionnaire regarding their understanding of the prescription, their motivation for obtaining and wearing the orthotics, their confidence in the orthotics' effectiveness, and their pain. Continuous variables were measured by a 100 mm Visual Analog Scale (VAS), the upper and lower boundaries of which were descriptive (i.e., "Not confident at all" and "Completely confident"). Patients indicated their answers with an X on the line. The dancers were instructed to obtain their orthotics from a single manufacturer to minimize variability in type and to take advantage of the fact that durability of orthotics has historically been obtained from this vendor. Dancers were invited to participate in the second phase of the study (posttreatment follow-up) if they met the criteria mentioned above and had worn the orthotics for a minimum of 6 weeks. After a minimum period of 8 weeks following their first visit, all patients were invited to return to the clinic for measurement of the medial longitudinal arch angle of the foot and to fill out a 26-item follow-up questionnaire. This questionnaire inquired about demographic information, dancers' compliance in obtaining and wearing the orthotics, their experience and satisfaction with the orthotics, the financial costs of orthotics, and current level of pain as related to the chief complaint. As in the first questionnaire, continuous variables, such as satisfaction rate and pain, were measured using a VAS scale.

Measuring Pain Reduction: In both questionnaires, the dancers in the prospective group were asked to give their current estimation of pain level of the chief complaint thought to be related to hyperpronation by placing an X on the VAS scale. The pain reduction percentage was calculated by dividing the difference in pain pre- and post-treatment by the pre-treatment pain intensity and multiplying by 100.[36]

Estimating the Severity of Hyperpronation: The degree of hyperpronation was graded based on a scale that the senior investigator has been using clinically for over 20 years. In this exam, hyperpronation is assessed by squatting in front of the barefoot patient and observing "rolling in" of the feet and the valgus position of the ankle in a relaxed stance after maximal inversion and eversion of the ankles. Then the hallux is extended (dorsiflexed) at the MTP joint while the other digits remain on the floor. This maneuver, often called the "Hübscher maneuver" or "Jack test,"[37] causes inversion of the foot back to neutral positioning. The visual estimation of the amount of "roll in" while the dancer is at rest, plus the degree of correction needed to obtain neutral position via hallux extension, are then used to grade the severity of hyperpronation from + to +++ (mild to severe). Each foot is examined separately. Thus, a patient with +/++ in the chart implies a right foot with a mild degree of hyperpronation and the left foot with moderate hyperpronation. While each foot is examined separately, the dancer is classified overall as a mild, moderate, or severe hyperpronator based on the more severe foot.

Measuring the Effect of Orthotics on the Medial Longitudinal Arch Angle: In the prospective study, the Foot Build Registration System (FBRS) was used to investigate and document changes in the medial longitudinal arch angle (angle between hallux, navicular bone and medial calcaneus) due to orthotics wear in the posttreatment follow-up group (Fig. 3).[8] This system consists of a round Trespa® plate (79 x 79 cm), which encloses a safety glass plate (49 x 49 cm) and is surrounded by a steel frame. A digital camera can be attached to the FBRS so that images can be made from the anterior, posterior, lateral, and medial view of the foot. The measurements were made with the dancer standing in a relaxed first position with one foot on the platform and the other on a step 30 cm above the platform.

Retrospective Chart Review

At the time of chart review, the readily available (last 6 years) archive of the clinic's patient data filing system stored a total of 2,427 dancers' charts. These were all non-selectively and alphabetically explored to identify patients who were diagnosed with complaints related to hyperpronation of the feet and prescribed orthotics. This review did not include the charts of patients in the prospective group. Patients with available email addresses were sent an electronic questionnaire identical to the 26-item follow-up questionnaire used in clinic by the prospective study patients. Up to three attempts were made to contact each individual patient. The dancers had to meet the same inclusion criteria as those in the prospective study.

Statistical Analysis

Results from the prospective and retrospective groups were analyzed separately to determine

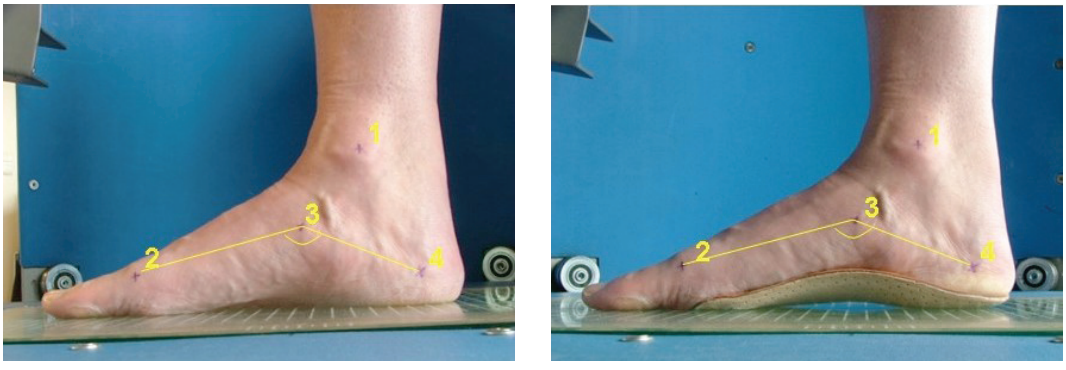

Figure 3 Four anatomical landmarks are used to calculate the medial longitudinal arch of the foot using the FBRS: 1. the medial malleolus, 2. the medial aspect of the hallux, 3. the navicular bone, and 4. the medial aspect of the calcaneus. A, The medial angle was measured while standing barefoot and B, while wearing a custom made three-quarter length insole in a relaxed stance position on the flat surface of the FBRS.

any statistically significant differences between the groups. When present, such differences were recorded. In the absence of significant differences, results of both groups were pooled for analysis. Statistical analysis was performed using SPSS (version 17.0) statistical software (Chicago, Illinois, USA). For continuous variables, the Students' ttest was used for independent samples or two-way ANOVA to calculate the statistically different degrees of hyperpronation in the prospective and retrospective groups. The Fisher's Exact Test was used for dichotomous variables. To analyze pain reduction, we used the Students' t-test for paired samples, with the level of significance set at $p < 0.05$. On the 100 mm VAS scale, patient satisfaction was defined as greater than or equal to 60 mm, and significant relief of complaints during dance activity at 30 mm or more. A decrease in pain of 15 mm or more on the VAS scale was considered significant.[38] "Regular" wear of orthotics was set at 5 days or more per week, or 6 hours or more per day on the days of usage for 2 or more days per week.

Results

Participation Prospective Study

In the prospective study, 76 patients participated in the pre-treatment physical exam and questionnaire. Of these, four patients subsequently cancelled their cooperation with the study, 13 patients did not meet the criterion of wearing their orthotics for at least 6 weeks, 33 did not respond to our contact, and 2 patients had provided invalid contact information. Hence, a total of 24 patients (2 males, 22 females; mean age = 25.0 ± 15 years; range 10 to 68 years) met the criteria for post-treatment analysis and returned for the follow-up exam and 26-item questionnaire (32%).

Retrospective Study

In the retrospective chart review, 739 of 2,427 patients met the inclusion criteria (30%), and 322 of these patients had valid email addresses. Of the 322 patients, 16 had stopped dancing, and 224 did not respond to our emails. A total of 81 patients (12 males, 69 females; mean age = 31.0 ± 13 years; range 14 to 65 years) were included in the retrospective part of this study (25%). Demographic information is displayed in Table 1.

Table 2. Dancers' Compliance with Orthotic Prescription

Usage pattern		
Obtained orthotics, N (%)	91	(86.7)
Wears orthotics regularly,* N (%)	47	(51.6)
Initially obtained orthotics but stopped wearing them, N (%)	30	(33.0)
Number of hours per day of wear, M (SD)	7.5	(3.0)
Number of days per week of wear, M (SD)	6	(1.5)
Percentage pain reduction, M (SD)	25.9	(25.0)

*≥ 5 days per week or ≥ 6 hours per day and ≥ 2 days per week.

Table 3. Dancers' Reasons for Compliance and Noncompliance with Orthotics

Variable	**Dancers who obtained orthotics (N = 91)**	**Percent**
Reason for wearing		
▪ Feels more stable	32	32.5%
▪ Doctor told me to	29	31.9%
▪ Less pain	28	30.8%
Reason for NOT wearing*		
▪ Pain went away	13	33.3%
▪ They hurt	9	23.1%
▪ Don't fit in all shoes	9	23.1%
▪ Too cumbersome	3	7.7%
▪ Don't think they'll work	2	5.1%
▪ Forget to put them in shoes	1	2.6%
▪ No reason	2	5.1%

*Of the 39 dancers who had not worn the orthotics regularly or stopped wearing them completely.

Degree of Hyperpronation

Of the 105 patients (210 feet) who participated in the 26-item questionnaire regarding compliance and satisfaction (81 from the retrospective group and 24 from the prospective group), 81 patients' degree of hyperpronation had been noted in their chart (162 feet documented, 77%). Patients were separated into mild, moderate, and severe groups based on their more severely hyperpronated foot. According to this definition, 39.5% (N = 32) of patients were classified as mild (+), 46.9% (N = 38) as moderate (++), and 13.6% (N = 11) as severe (+++) hyperpronators. There was no significant difference between the degree of hyperpronation in the prospective and retrospective groups ($X^2 = 3.61$, $p = 0.16$).

Compliance

Of the 105 dancers included in the study, 91 dancers (87%) obtained the prescribed orthotics. All (100%) of the 24 patients in the prospective group obtained the orthotics, as did 83% (N = 67) in the retrospective group. At a mean follow-up period of 36.6 months (± 39.6 months), 61 of 91 dancers (67%) still wore the orthotics at the time of inquiry. Among current wearers, the average time spent wearing the orthotics was 6 days per week (± 1.5 days) and 7.5 hours per day (± 3 hours). Fortyseven dancers wore their orthotics regularly at time of follow-up (52%), as per the definition of regular wear in Methods. Among all dancers who purchased orthotics, 52 had worn them regularly (57.1%) and 39 had worn them every day (42.9%) during the time they wore the orthotics the most (Table 2). There were no significant differences found in compliance with wear between the prospective and retrospective groups in days per week (CI -0.02–1.55, $p = 0.06$) and hours per day (CI -0.92–2.40, $p = 0.38$). On one-way ANOVA, there were no differences in compliance with wear between the different degrees of hyperpronation in days per week ($F = 92$, $p = 0.41$) and hours per day ($F = 0.46$, $p = 0.63$), as shown in Table 3.

Dancers stated that the main reasons for wearing the orthotics were that they "felt more stable" (N = 32, 32.5%), "because the doctor told [them] to" (N = 29, 31.9%), and because they had "less pain when [they] wore them" (N = 28, 30.8%).

Among dancers who had not worn the orthotics regularly (N = 9) or stopped wearing them completely (N = 30: total N = 39, 42.9%), their reasons for infrequent use or cessation were: "My pain went away" (N = 13, 33.3%), "They hurt" (N = 9, 23.1%), "They don't fit in all the shoes I want to wear" (N = 9, 23.1%), "They are too cumbersome" (N = 3, 7.7%), "I don't think they work" (N = 2, 5.1%), and "I forget to put them in my shoes" (N = 1, 2.6%). Two patients (5.1%) gave no reason (Table 3).

Between the prospective and retrospective groups the reasons for wearing the orthotics were equally distributed ($X^2 = 4.00$, $p = 0.26$). The given reasons for wearing the orthotics were not correlated with the degree of hyperpronation ($X^2 = 6.41$, $p = 0.38$). There were no differences

in reasons for cessation in wearing the orthotics between the prospective and retrospective groups ($X^2 = 2.18$, $p = 0.70$), and these reasons also did not correlate with the different degrees of hyperpronation ($X^2 = 10.24$, $p = 0.25$).

Decrease in Pain

There was a significant decrease in pain from the day of orthotics prescription to follow-up (25.9%, or 18.9 mm decrease on the VAS, CI 6.6–30.9, $p = 0.005$) in patients of the prospective study group. There was no significant relationship found between the decrease in pain and the degree of hyperpronation ($F = 1.70$, $p = 0.20$).

Satisfaction, Relief, and Improvement in Dance

The average satisfaction in all dancers who obtained the orthotics was 67.9 mm (± 26.5) on the 100 mm VAS, which was significant according to the definition of significance set prior to testing at 60 mm or more. The mean satisfaction was 61.2 mm (± 27.0) for mild hyperpronators, 72.5 mm (± 22.6) for moderate, and 67.2 mm (± 34.2) for severe hyperpronators. The mean reduction in symptoms was 58.3 mm (± 28.3), which was considered to be significant according to our definition of 30 mm or more. Per group, the average report of relief was 57.2 mm (± 30.2), 55.5 mm (± 26.5), and 62.3 mm (± 31.7) for mild, moderate, and severe hyperpronators, respectively.

Among all dancers, improvement in ability to dance without symptoms was 45.7 mm (± 27.9), considered to be significant according to our prior set definition of 15 mm or more. Per group, this improvement was 42.8 mm (± 41.8), 45.4 mm (± 26.5), and 54.1 mm (± 33.8) for mild, moderate, and severe hyperpronators, respectively.

Dancers with a moderate or high degree of hyperpronation reported the most satisfaction, relief, and improvement in ability to dance without symptoms, although not significantly ($F = 1.27$, $p = 0.28$; $F = 0.23$, $p = 0.80$; and $F = 0.75$, $p = 0.47$ for satisfaction, relief, and symptom-free dancing, respectively). There were also no differences in reported subjective effectiveness between the prospective and retrospective study groups (CI -15.00–12.20, $p = 0.84$ for satisfaction, CI -24.82–1.99, $p = 0.09$ for relief, and CI -14.01–12.90, $p = 0.94$ for improvement in dance).

Effect of Orthotics on the Medial Longitudinal Arch Angle

Of the 24 patients in the prospective study's follow-up group, 16 patients (32 feet) were measured with the FBRS (Foot Build Registration System). Six feet were excluded due to insufficient camera images; therefore, 26 feet were included for data-analysis. The mean medial angle with the dancer standing barefoot on the surface was 142.2° (± 9.4°) and 139.6° (± 9.4°) when standing on the surface while wearing orthotics. The mean decrease of the

medial angle was 0.9° (± 1.9°), which was statistically significant (CI 0.08–1.65, p = 0.03).

Discussion

Hyperpronation of the foot is a common finding upon physical exam, and it is thought to be related to, if not causative of, certain somatic complaints and injuries. Despite lack of evidence regarding their effectiveness, orthotics are widely prescribed for the conservative management of foot hyperpronation among dancers and non-dancers alike. This is the first study to examine compliance with wear and perceived effectiveness of orthotics in dancer-patients seen at a high-volume center for performing arts medicine.

Compliance

Dancers showed a high rate of compliance in acquisition and long-term use of prescribed orthotics. Sixty-seven percent of patients still wore their orthotics at the time of follow-up, including those who had had the orthotics for up to 6 years. Seventyseven percent of these patients wore the orthotics regularly. This rate of compliance is likely elevated by selfselection for study participation of more compliant dancers, or those who had a good outcome. The investigators would have liked a higher response rate and fewer patients lost to follow-up for greater accuracy. However, the rate of acquisition may also be higher in this study than what would be expected in other countries because dancers living in The Netherlands are insured, and orthotics are partially covered. The cost of orthotics is around 170 euros.

The reasons identified for dancers' compliance with orthotics acquisition and wear were interesting. Across multiple fields of medicine, patients' compliance with doctors' recommendations has been studied,[39] including health care seeking behavior among dancers.[40] In this study, the most popular reason (32%) for obtaining orthotics was "Because the doctor said so." This emphasizes the physician's role in the doctor-dancer relationship. It is important that doctors spend time explaining hyperpronation and its somatic sequelae to dancers, as well as how orthotics and exercises may help to improve or prevent complaints in the future. Increased patient education may mean more compliance among dancer-patients.[41] In particular, dancers may find it useful to know that orthotics appear to decrease the medial longitudinal arch angle and degree of hyperpronation according to the FBRS, as well as decrease pain when worn compliantly for approximately 6 weeks.

Regarding dancers' reasons for stopping their wear of orthotics or for not wearing them at all, the most popular reason cited (33%) was that the dancer's pain went away. This response was not pursued further in this study, but it may indicate successful therapy in those dancers who wore their orthotics and then stopped. The relationship between orthotics usage and pain should be further evaluated and clarified.

Other reasons dancers gave for stopping their use of orthotics were "They hurt" and "I don't think they work." Discomfort is, unfortunately, common in the first 2 to 4 weeks of wearing custom shoe inserts. Orthotics are meant for long-term wear, and treatment should not be considered a failure because of discomfort early on. It is important for the prescribing physician to educate the dancer about this ahead of time; that the discomfort is only temporary when, and if, it occurs. Nevertheless, severe discomfort should prompt follow-up with the physician to ensure that the orthotics are moulded properly to the patient's feet.

The proper duration of orthotics wear is not yet clear. In the clinical setting, orthotics are typically prescribed for a minimum of 3 to 6 months. Anecdotally, in the investigators' clinic most dancers do not like the idea of having to wear the orthotics indefinitely. We therefore instruct each patient to wear the orthotics for a minimum of 3 to 6 months and then stop, provided that the chief complaint has improved or disappeared. The dancers are advised to start wearing them again if symptoms recur. If complaints persist despite regular wear of the orthotics for 3 to 6 months, the dancer is usually advised to stop wearing them, unless symptoms are worse without them. Regular clinical follow-up with dancers after they have been prescribed orthotics is important to re-evaluate symptom resolution.

Effectiveness

Based on the significant rate of satisfaction with orthotics therapy (67.9%), the reduction of somatic complaints (58.3%) and the improvement of perceived ability to dance without symptoms (45.7%), it can be assumed that orthotics therapy is effective, even when worn only in street shoes. There was a general trend in the data to a lower rate of effectiveness among mild pronators compared to moderate or severe, but this did not achieve significance. Decreased symptoms during dance activity due to wearing orthotics during non-dance activity may suggest a translational component to regular orthotics wear, such as muscle memory for correct lower extremity alignment, or more body awareness in the dancer so that she consciously corrects the alignment while wearing unsupportive dance shoes.

The medial longitudinal arch angle of the ankle was significantly decreased with the orthotics (139.6° vs. 140.2°, mean decrease 0.9° ± 1.9°), which may have contributed to the decreased pain and symptoms during dance reported by the dancers in this study. Orthotics will not "cure" hyperpronation; they are intended to correct malalignment. Realignment may, in turn, relieve stress on the foot-ankle complex, redistribute forces more equally up the kinetic chain, and relieve symptoms. Conscious realignment and avoidance of compensatory strategies,[4] especially when performing the classical ballet positions, is important to incorporate into correct dance technique.

Limitations

The major limitation of this study was its poor response rate. Many dancers who were considered for the prospective group were not compliant with 6 weeks wear of orthotics. The majority of the follow-up (drop-out) issues in the retrospective study were due to invalid or absent contact information, as well as the potentially long time lapse between consultation and request for participation (up to 6 years).

Although it is generally true that prospective data have a higher level of reliability than retrospective data, we decided not to draw this distinction. Because there were no significant differences between the two study groups in compliance, degree of hyperpronation, or subjective effectiveness, these data were pooled. We were unable to pool the data regarding decrement in pain or change in the medial longitudinal angle, because these had only been measured in the prospective (smaller) group, which may affect the generalizability of these results.

The study results pertain only to rigid, three-quarter length, custom made orthotics. The effectiveness of other orthotics cannot be extrapolated.

Socioeconomic status was not included in our analysis of compliance due largely to the fact that insurance is mandated in The Netherlands.

Finally, only the decrease in medial longitudinal angle in stance position was measured, rather than during dynamic activities such as walking.

Conclusion

Symptomatic hyperpronation is common among dancers presenting to the physician's office, and orthotics are frequently prescribed for conservative management. Dancers in this study showed a high rate of compliance in obtaining and wearing these devices. The orthotics were associated with decreased pain and improved ability to dance without symptoms. However, because of the small number in the prospective study group, further research is needed to investigate the decrease in pain and medial ankle angle due to orthotics in a larger study group. Dancers with a moderate or high degree of hyperpronation appeared to experience the most relief with regular orthotics wear.

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Relevé in a normal dancers' foot

Overview of the left foot, ready for open release of the flexor hallucis longus tendon sheath and removal of an os trigonum via the posteromedial side

PART 2 (chapters 7-9)

Results of conservative and operative treatment of Limited and painful 'Relevé' in Dancers due to Posterior Ankle Impingement Syndrome (PAIS) and Flexor Hallucis Longus (FHL) Tendinopathy: *Dancers' Heel and Dancers' Tendinitis*

Chapter 7

Results of Treatment of Posterior Ankle Impingement Syndrome and Flexor Hallucis Longus Tendinopathy in Dancers: A Systematic Review

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Results of Treatment of Posterior Ankle Impingement Syndrome and Flexor Hallucis Longus Tendinopathy in Dancers: A Systematic Review

7

Abstract

Dancing on pointe and relevé require extreme plantar flexion of the talo-crural joint. Hence, these positions may lead to Posterior Ankle Impingement Syndrome (PAIS). PAIS often coincides with flexor hallucis longus tendinopathy (FHL tendinopathy, or *Dancers' tendinitis*). Both injuries can appear in isolation as well. The goal of this review is to evaluate the results of conservative and operative treatment (both open and endoscopic) of PAIS and/or FHL tendinopathy in dancers, and the available levels of evidence. It also offers an insight into the history of dance medical publications on this subject. In October, 2016, a systematic search of PubMed, Embase, COCHRANE, CINAHL, Web of Science, and (in French) ScienceDirect databases was undertaken. Five hundred and seventy-six publications were found, of which 74, including 36 expert opinion reviews, described treatment in dancers, starting with A.J. Howse in 1972 and W.G. Hamilton in 1977. A total of 27 reported the results of operative treatment in 376 ankles (344 open, 32 endoscopic) in 324 dancers. The outcome was good to excellent in most cases (89%). Mean period of return to dance for all surgeries combined (PAIS and/or FHL tendinopathy, open and endo) was 11 weeks (range: 4-36 weeks), and for isolated FHL tendinopathy 16 weeks (range: 8 - 36 weeks).

Only six publications reported the results of conservative treatment in 33 ankles (13 PAIS, 20 FHL tendinopathy) of 28 dancers, not allowing any evidence-based recommendations.

Most studies failed to include dance-specific baseline characteristics, like dance style and level of participation.

We concluded that only retrospective studies with levels of evidence four and five show that operative treatment for PAIS and / or FHL tendinopathy is successful with few complications. Studies on conservative treatment hardly exist and are of low quality.

Since isolated PAIS, PAIS combined with FHL tendinopathy, and isolated FHL injuries appear to be different pathological entities, more research is needed to find out in which cases early operative management should be considered or avoided, taking into account demography, dance type, and level of participation. The same applies to defining the place of endoscopic surgery in dancers, and being able better to predict which pathology is likely to produce worse outcomes or delay in return to dance. Future research should have a prospective design, including dance-specific outcome scores both pre- and post-treatment. Furthermore, preferably a prospective randomized controlled design should be used to compare different conservative and operative treatment options.

Introduction

In a dedicated dance-medical orthopaedic referral center 454 of 587 injuries (77%) in 345 dancers involved the lower extremity. The highest proportion (27%) involved the ankle. More than half of those were Posterior Ankle Impingement Syndrome (PAIS)or flexor hallucis longus tendinopathy (FHL tendinopathy).[1] A similar pattern is seen in other recent studies on dancers' injuries: the highest numbers of injuries in professional and pre-professional dancers (mainly ballet) concern the foot and ankle, the commonest being ankle sprains, followed by PAIS and FHL tendinopathy.[2;3] Given the frequency of PAIS and FHL tendinopathy in dancers, knowledge of their optimal treatment in dancers is mandatory. That is why we decided to perform this systematic review.

Dancing *on pointe* occurs predominantly in ballet (see Fig.1). Relevé is an ankle-foot position typical of all forms and styles of dance around the world, and is required in virtually every choreography (see Fig.2). In dance the ankle is frequently, actively, and with prolonged forced taken into extreme plantar flexion. This means that the foot-ankle joint complex is fully weight bearing at the end range of joint motion ("close-pack"). Both in relevé and on pointe forces are transmitted directly through the contacting bones, with neither intrinsic shock damping by compensatory joint motion nor extrinsic shock absorption by the shoe or the floor. This leads to repetitive peak stress on the contacting bony structures in the back of the ankle and may contribute to the frequency of PAIS in dancers.

Figure 1: On pointe

Figure 2: Relevé

In some sports extreme plantar flexion of the ankle is required periodically and suddenly in a passive manner (by external force, e.g., soccer during certain forms of kicking) or briefly in an active manner (e.g., gymnastics and other artistic sports), but never in the controlled, persistent, extreme, active, and fully weight bearing manner as is so frequent in dance.

In kicking a ball the talo-crural and subtalar joints are non-weight-bearing; hence, there is no tendency of the talus (talo-crurally) and calcaneus (subtalarly) to slide posteriorly, adding to the impingement. Secondly, in kicking the calcaneus is not pulled up by the triceps surae. That this is important is biomechanically logical and is illustrated by the fact that in PAIS testing (plantar flexion test) the pain will mainly be provoked if the calcaneus is pressed up simultaneously. Of course in gymnastics and other "artistic" sports, as well as in many ADL activities, this happens briefly, but again, the persistent, repeated combination of these factors is unique to dance. As a consequence PAIS is a typical and common dancers' injury, and sometimes is referred to as dancers' heel.[4]

In dancers FHL tendinopathy, posteriorly and plantarly to the medial malleolus and sustentaculum tali, regularly coincides with PAIS (estimates vary between 26% and 63%),[5;6] and sometimes is referred to as dancers' tendinitis.[7;8] The etiology of FHL tendinopathy in dancers is not fully understood. It may be related to anatomical deviations,[9;10] faulty dance technique,[11] and possibly FHL activity in certain dance positions and jumps.

Successful operative treatment at a youthful age and/or a healthy worker effect (only the strongest persist) were the suggestions of these authors to explain the fact that they found the percentage of ankle problems to diminish with age from 27% in a group of dancers of all ages (n = 345), half of them having PAIS and/or FHL tendinopathy, to 3% in dancers 45 years of age and older.[1]

Conservative management of these diagnoses for at least 3 months is likely to be the first choice of dancers and their doctors alike. Non-surgical modalities may include correction of dance technique and alignment, a period of relative rest and/or modification of (dance) activities, physical therapy,[12] and arch supports.[13] Only in selected cases of PAIS (soft tissue impingement rather than bony impingement), not in FHL tendinopathy, injections (local anesthetic with corticosteroid) may be beneficial.[5]

If conservative treatment for PAIS and/or FHL tendinopathy fails, surgery is recommended. This can be done via an open procedure, with either a medial or a lateral approach. The medial

approach is used in isolated FHL tendinitis or in cases with a combination of FHL tendinitis and (bony) PAIS. The lateral approach is used when the diagnosis is limited to posterior ankle impingement by a bony impediment.[5;9;10;14] In 2000 a hindfoot endoscopic technique was introduced by van Dijk.[15-18]

One of the pioneers of orthopedic dance medicine is E. Thomasen. In his book *Diseases and Injuries of Ballet Dancers*, published in 1982, he describes operative treatment of FHL tendinopathy and/or posterior impingement of an os trigonum or hypertrophic posterior process of the talus (Stieda's process).[10] His extensive description includes details on anatomy and symptoms in 72 ankles of 69 ballet dancers, making it the largest case series to date, and still covers about 20% of all dancers with PAIS and FHL tendinopathy described in the literature (see Table 2). In the introduction to his book Thomasen states that these injuries are peculiar to dancers, because dancers' positions and movements are different from "normal" positions and movements in sports and daily life. Also, A.J. Howse emphasized in 1972 that an os trigonum causes symptoms only when the foot is forced to do something abnormal.[19]

The preparation of this review offered an insight into the history of dance medical publications on this subject: thirty-six expert opinion publications mentioned conservative or surgical treatment of posterior ankle problems in dancers.[8;12;14;19-51] These opinions were relevant, but mostly empirical, lacking original research and evidence, although they usually included a brief review of the available literature, referencing publications that were also found and documented in our systematic search. A. J. Howse in 1972 was the first author to describe os trigonum syndrome in dancers and the result of surgical treatment: "excision of the extra bone relieves the symptoms."[19] W. G. Hamilton was the first author to describe FHL tendinopathy in dancers, coined by him as "dancers' tendinitis" in 1976.[7;8] G. J. Sammarco in 1979 was the first to describe triggering of the hallux in dancers due to FHL tendinopathy.[52]

Given the specific and different demands of dance compared to sports, studying the treatment outcome for PAIS and FHL tendinopathy in dancers specifically is of paramount importance. The results in sports cannot be extrapolated to dance. The goal of our review is, therefore, to study systematically the current medical scientific literature on the results of conservative and operative (both open and endoscopically) treatment for PAIS and/or FHL tendinopathy in dancers, and evaluate the available levels of evidence.

Methods

Without restriction of date a systematic search in English and French only was performed in October, 2016, using PubMed, MEDLINE, Embase, Cochrane, CINAHL, Web of Science (for English literature), and ScienceDirect (for French literature) databases. Our search criteria encompassed anatomy (e.g., ankle, talo-crural, talus, os trigonum, Stieda's process, flexor hallucis longus), type of injury (primarily ankle impingement, tendinitis, tendinopathy, Shepherd's fracture, and trigger toe), and type of activity (dance). Each search term included all possible synonyms and word-roots. The type of treatment was not included to prevent undesirable and unnoticed exclusion. For the same reason the criterion posterior was avoided. Dancers were specified as persons who, either as an amateur or as a professional, danced at least 3 times per week in an organized manner, regardless of age, sex, nationality, or dance style.

The complete systematic review protocol was recorded under number 48258 at Prospero, the international prospective register of systematic reviews (http://www.crd.york.ac.uk/prospero). The search strategy, including all detailed search criteria, like MeSH terms, can be found and downloaded via http://www.crd.york.ac.uk/PROSPEROFILES/48258_STRATEGY_20161020.pdf.

Two readers (first and second author) independently and blinded selected the articles, using the principles of the Prisma statement,[53] and five pre-specified eligibility criteria:

1. all studies and articles of all levels of evidence, from expert opinions and case reports to randomized clinical trials and systematic reviews, which report, but are not necessarily limited to, posterior ankle problems, more specifically PAIS and FHL tendinopathy, including, but not necessarily limited to, dancers.

From this first survey we selected all articles describing:

2. dancers only, or reporting on dancers as a separate group;
3. any type of treatment of PAIS and/or FHL tendinopathy in dancers;
4. results of conservative treatment of PAIS and/or FHL tendinopathy in dancers;
5. results of operative treatment, both open and endoscopic procedures, in dancers.

Conflicts of opinion regarding articles were referred to a third reviewer (third author). All three reviewers were MD's, experienced in dance medicine. The selected articles were further rated according to their study design and their level of evidence according to "Levels of Evidence for Primary Research Questions" (See Table 1).[54;55]

Table 1: Study Type: Therapeutic—Investigating the results of a treatment.

Question: Does this treatment help? What are the harms?
Level 1: Randomized controlled trial (a meta-analysis of RCT's is the highest level)
Level 2: Prospective cohort study or observational study with dramatic effect
Level 3: Retrospective cohort study or case-control study (comparative)
Level 4: Case series or historically controlled study (non-comparative)
Level 5: Mechanism-based reasoning (including expert opinions and case reports)

Adapted from Instructions for Authors of the Journal of Bone & Joint Surgery (JBJS)

The quality of the included publications was critically appraised using the system of the Grading of Recommendations Assessment, Development and Evaluation working group (see: www.gradeworkinggroup.org).[56] We checked demographic data, type of injury (soft tissue or different types of bony impingement[57] and/or FHL tendinopathy), type of conservative treatment or operation, duration of follow-up time, outcome measures (imprecision, publication bias, indirectness), heterogeneity or inconsistency of results between studies, and the effect size. Brief descriptive statistics of case reports were included, but for analysis of qualitative and quantitative outcome we used level of evidence four and higher studies only

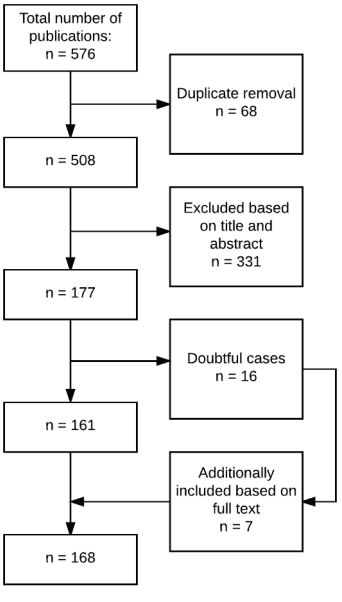

Figure 3: Flowchart total search

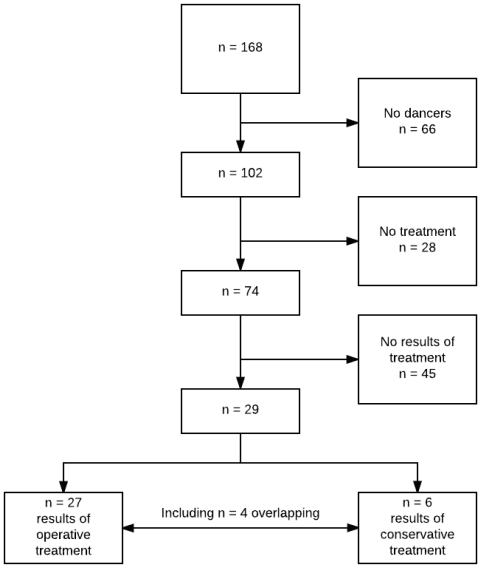

Figure 4: Flowchart final selection

Results

Our search resulted in 576 publications. After extracting 68 duplicates, the remaining 508 publications were scored to conform to the first eligibility criterion (see Fig. 3 flowchart). The resulting 168 included publications were scored to conform to eligibility criteria 2-5 (see Fig. 4 flowchart). In 117 instances the full text was obtained and studied, because title and abstract alone were not sufficient to determine eligibility (data not shown).

Results of operative treatment of PAIS and/or FHL tendinopathy in dancers: The results of operative treatment in dancers were reported in 27 publications: nine case reports,[15;52;58-64] 14 case series,[5;9;65-76] two cohort studies,[77;78] one expert opinion,[79] and one systematic review.[80]

One expert opinion review was initially included but had to be excluded in the second instance due to publication bias, since the same groups of dancers were also studied in depth in 2016 in one of the two cohort studies.[77;79]

The systematic review was excluded to avoid duplication of some articles, but we decided to use it in the discussion to give us the opportunity to check for completeness of our search and to compare our findings.[80]

An overview of dancers with surgical treatment of ankles for PAIS and/or FHL tendinopathy in the remaining 25 articles, level of evidence four and five observational studies only, is shown in Table 2.

Table 2: Numbers of operated dancers and ankles found in 25 * of the 27 publications reporting the results of operative treatment of PAIS and / or FHL tendinopathy in dancers, found in the search for this systematic review until October 1st, 2016

	Total		Open		Endo	
9 case reports	16	21	10	14	6	7
14 case series	266	313	257	303	9	10
2 cohort studies	42	42	27	27	15	15
Subtotal 14 case series and 2 cohorts	308	355	284	330	24	25
Total found in search (25 publications)	324	376	294	344	30	32
Thomasen's book:	69	72	69	72	0	0

* Two publications are used in the discussion only, and not included for analysis in this table: an expert opinion review article [79] reporting the same groups of dancers as in one of the two cohort studies, and a systematic review. [80]

Qualitative and quantitative outcome: For the analysis of qualitative and quantitative outcome, 14 case series [5;9;65-76] and two cohort studies[77;78] were available. Overall in these 16 articles the scoring of results was:

- Qualitative, using personalized scoring systems (e.g., excellent, good, fair, poor, symptom-free, pain-free, etc.): in 10 case series until 1999;
- Functional, such as return to dance or return to previous activity, in 12 case series and the two cohort studies;
- Quantitative, using validated general scoring systems, since 2002: in three case series[66;74;75] pre- and post-operative outcome scores were used, post-operative scoring in one case series.[70] One cohort study used pre- and post-operative quantitative scoring but did not separate dance and sports.[78] No author used a dance-specific outcome score.

We combined the scoring in 308 dancers and 355 operations of the 14 case series and two cohort studies, lumping together all different scoring systems (Table 3).

Table 3: Overall results of scoring of all qualitative and quantitative scoring systems combined in 308 dancers (355 operations) based on 14 case series and two cohort studies

Excellent	210	68%
Good	64	21%
Fair	20	7%
Poor	13	4%
Lost for follow up:	1	-
Stopped dancing for unrelated reasons:	4	-
Not specified *	7	-
Total	319	**

* One cohort study did not score dance and sports separately. [78]

** Most authors scored dancers, two authors (three different case series) scored procedures. Since it is impossible to separate those dancers that had bilateral procedures, the total number (319) includes 11 bilateral operations in 308 dancers. We found no report of bilateral procedures functioning differently or needing more time for rehabilitation.

Functional outcome: Functional scoring ("return to dance") was the primary outcome measure in 14 publications. Hamilton was the only author providing a dance-specific differentiation in return to dance: "barre exercises," "participation in class," and "return to full performance". [5] One publication distinguished between unspecified return to dance (7.8 weeks) and return to dance pain-free (17.7 weeks).[68] In the other studies definitions of return to dance were inconsistent or missing.

Combining the results of all series that scored functional outcome, regardless of the type of operation, we found 11 weeks as mean time to (unspecified) return to dance in general, with a

range from 4 to 36 weeks. Dancers with a combination of PAIS and FHL tendinopathy returned to dance in seven weeks, dancers with isolated FHL tendinopathy (without PAIS) in 16 weeks. Both groups were operated via an open posteromedial approach (see Table 4).

Table 4: Mean return to dance per pathology and per type of operation (14 case series and four series in two cohort studies)

	No of series	No of ankles	Mean RtD (weeks)	Range (wks)
All surgeries *	12	212	11	4 - 36
All surgeries **	13	253	13 **	4 - 96
All open surgeries *	9	191	11	4 - 36
All open surgeries **	*10*	*232*	*14* **	*4 - 96*
All endoscopic surgeries	3	21	10	6 - 20
All open PAIS (PL & PM)	6	133	11	4 - 24
Open PAIS&FHL (PM)	2	31	7	3 - 20
Open FHL (PM)	2	27	16	8 - 36
Open PL PAIS	3	28	12	4 - 24
Open PM PAIS	2	83	10	3 - 20
Endo PAIS	3	21	10	6 - 20

* in 5 studies either return to dance, or pathology, or procedure was not specified. One study (41 ankles) excluded (see **)

** one extreme 'outlier' (96 weeks RtD) in a series of 41 ankles included (see remark S6 in Table 6).

Endo: via endoscopic technique; FHL: flexor hallucis longus tendinopathy; PL: open via posterolateral approach; PM: open via posteromedial approach; PAIS: posterior ankle impingement syndrome; RtD: Return to Dance

Table 5: Included case reports (level of evidence 5) conforming to eligibility criterium nr. 5

Table 5: Included case reports (level of evidence 5) conforming to eligibility criterium nr. 5

	Year	Author	Dancers	Ankles	Dance	F/M	R/L	Age	Pathology	Procedure	FU	Result	RtD
1	1979	Sammarco	2	3	Ballet	2/0	1/2	23	FHL ('trigger toe')	Open PM	3 m	NS	12 w
2	1981	Garth	1	2	Ballet	1/0	1/1	21	FHL	Open NS	7 m	NS	not yet
3	1982	Quirk	2	3	Ballet	1/1	1/2	17	PAIS	Open PL	36 m	2 excellent	12 w
4	1985	Lereim	2	3	Ballet	1/1	2/1	20	FHL ('trigger toe')	Open NS	6 m	1 exc. 1 good	12&24w
5	2000	Van Dijk	1	2	Ballet	1/0	1/1	22	FHL&PAIS	Endo	30 m	1 excellent	8 w
6	2008	Almazan	1	1	Ballet	1/0	1/0	17	PAIS	Endo	NS	1 excellent	8 w
7	2009	Albisetti *	2/1 *	2/1 *	Ballet	2/1	NS	14	PAIS	Open NS / endo	NS	2 exc / 1 good *	6w/9w *
8	2010	Porter	1	1	Ballet	1/0	0/1	17	FHL	Open NS	NS	NS	NS
9	2013	Ahn	3	3	NS	NS	NS	NS	PAIS	Endo	NS	3 excellent	10 w
		Total	16	21	Ballet	10/3	7/8	19,7	FHL 4, PAIS 4, mixed 1	Open 5, endo 3, mixed 1	3 – 30 m		6–24w

F, female; FHL, flexor hallucis longus tendinopathy; FU, follow-up; M, male; m, months; NS, not specified; PAIS, posterior ankle impingement syndrome; Procedure: open PL/PM, open posterolateral (PL) or open posteromedial (PM) approach; RtD, Return to Dance; w, weeks. Result: this is our interpretation of the text in the case reports: excellent means completely symptomfree dancing at former level, good means symptomfree dancing at former level with slight pain afterwards, NS means not (yet) returned to dance at FU. * Albisetti: in all fields the two Open NS cases are mentioned first.

Case reports: Descriptive statistics of the nine case reports on open and endoscopic procedures for PAIS and FHL tendinopathy in dancers are shown in Table 5.[15;52;58-64]
Six case reports[15;58-60;62;64] produced a non-validated qualitative outcome, totaling nine dancers (12 ankles) who had a good to excellent result. In the other three case reports[52;61;63] the outcome in four dancers (six ankles) was not reported. None used outcome scoring.

Case series: We identified 14 case series (266 dancers, 313 ankles) that reported the results of operative treatment of PAIS and/or FHL tendinopathy in dancers, either via an open operation (12 series, 257 dancers, 303 ankles) or performed endoscopically (two series, nine dancers, 10 ankles).[5;9;65-76] See Table 6.
Some studies identified factors associated with higher success rates. In a retrospective review of 41 operations in 37 dancers, the surgical procedure was more successful in professionals compared to amateurs.[5] Furthermore, return to a full dance (professional classical ballet) schedule was shorter (5 months) after the operation for isolated posterior impingement than after the combined procedure for posterior impingement and FHL tendinopathy, or after the operation for isolated FHL tendinopathy only (both 6 months).[5] The largest case series of dancers (PAIS only: 39 dancers, 60 ankles) found better results in those below the age of 17 years at the time of surgery; in this younger group 86% (18/21) showed good to excellent results compared to 67% (12/18) in older subjects.[73] The dancers of the Swedish National Ballet were the fastest to return to full performance dancing (mean 7 weeks, range 5-10 weeks) after an open posteromedial approach for PAIS and FHL tendinopathy.[76] FHL tendon injuries in dancers versus non-dancers both yielded "consistently good results".[72]
In 2016 the most recent series appeared, describing 40 ankles in 38 dancers who underwent os trigonum excision via an open posteromedial approach with FHL tenolysis, with an excellent result in 95% of the cases and one ballet dancer who, although she returned to ballet and modern dance, was unable to return to her pre-injury level of pointe because of posteromedial scar tissue. The average time to return to unspecified dance was 7.9 weeks, and the time to pain-free dance was 17.7 weeks.[68]

Cohort studies: In two retrospective cohort studies a total of 42 ankles in 42 dancers was studied, comparing the results of open operative treatment of PAIS (27 ankles in 27 dancers) and endoscopic treatment (15 ankles in 15 dancers). There were no FHL tendinopathy cases in these studies.[77;78] had occurred. In four case series (a total of 52 cases: 19 open posterolateral and 33 open posteromedial in 44 dancers) we assumed there were no complications. However, this was not mentioned specifically.[9;67;72;81]

In the first cohort study[78] (open: five dancers in 16 patients; endoscopic: two dancers in 25 patients) comparison of outcome in the total seven dancers was impossible, since they were not studied in detail, except for "*return to their previous level of performance,*" which was not further specified. Additionally, five patients in the total group of 41 patients underwent anterior ankle clean-out, but it was not specified in which group and whether they were dancers.
The second cohort study compared the results after open (n = 22) and endoscopic (n = 13) excision of an os trigonum in high-level ballet dancers.[77] However, the groups were not comparable: the dancers in the open group were considerably younger and rehabilitation was different between the two groups. Three of 22 patients in the open group and one of 13 patients in the endoscopic group had concurrent lateral ligament reconstruction. Thirteen of 22 patients in the open group had FHL tendon decompression compared with two of 13 patients in the endoscopic group. Return to dance after open surgical treatment in the two cohort studies took considerably longer (mean 15.1 weeks) than average (mean 11.2 weeks, see Table 4). All dancers were asymptomatic with regard to their ankle at the final follow-up visit (12 months).
As the comparative nature of both retrospective, comparative cohort studies posed serious limitations for our research question, we downgraded them to level of evidence four instead of three and combined them with the 14 case series to evaluate the results of operative treatment in dancers (see Table 6).

Surgical complications: In the 14 case series and two cohort studies we counted 22 complications in 355 operations in 308 dancers. Therefore, the overall complication rate, regardless of the type of operation, was 6.2%. There were 21 complications in 330 open operations (5,9%), and one (transient sensory neuropraxia of the tibial nerve)[74] in 25 endoscopic operations (4%). Complication rates were 12.8% for open posterolateral, and 4.3% for open posteromedial operations (see Table 7).
All but three complications were minor, like hematomas, superficial wound infections, and transient neurapraxias of the tibial or sural nerve. The three more serious complications (0.85% of 355 operations) were one hematoma that had to be surgically revised after an open posteromedial operation, [70] one case with complex regional pain syndrome after an unspecified open operation,[66] and one permanent sural nerve injury after an open posterolateral operation[78] (NB: it was not specified whether this last case was in dance or sports). For all nine case reports, three case series,[69;75;76] and an additional three series in the two cohort studies[77;78] (a total of 91 cases, 63 open and 28 endo, in 89 dancers) it was stated that no complications

Table 6: Results of operative treatment, both via an open approach and endoscopically, of posterior ankle impingement and flexor hallucis longus tendinopathy in dancers (eligibility criterium nr. 5). Fourteen case series (S1-S14) and two cohort studies (C1a/b-C2a/b)

Table 6: Results of operative treatment, both via an open approach and endoscopically, of posterior ankle impingement and flexor hallucis longus tendinopathy in dancers (eligibility criterium nr. 5). Fourteen case series (S1-S14) and two cohort studies (C1a/b-C2a/b)

Nr	Year	Author	Type of Dance	Dancers	Ankles	F	M	R	L	Age	Pathology	Surgery
			Level of participation								(number of ankles)	
a	1982	Thomasen †	Ballet	46 (34) ††	36	30	16	ns	ns	26	PAIS OT	Open PL
b	1982	Thomasen	Ballet	16 (10)	10	11	5	ns	ns	NS	PAIS PP	Open PL
c	1982	Thomasen	Ballet	52 (25)	26	38	14	ns	ns	25	FHL	Open PM
S1	1982	Hamilton	Ballet	16	21	10	6	ns	ns	26	PAIS & FHL	Open mixed
S2	1986	Brodsky	Ballet	6	8	5	1	5	3	21	PAIS	Open PL
S3	1991	Wredmark	Ballet	13	14	9	4	9	5	20	PAIS & FHL	Open PM
S4	1992	Marotta&Micheli	Ballet	12	15	ns	ns	7	8	23	PAIS OT	Open PL
S5	1996	Kolettis&Micheli	Ballet	13	13	13	0	4	9	20	FHL	Open PM
S6	1996	Hamilton (S6)	Ballet 30 Modern-Jazz 7	37	41	22	15	19	22	23	FHL 6, PAIS 9,	Open PL 6,
			Prof 31, amateurs 6								Mixed 26	Open PM 35
S7	1997	Heim & Siev-Ner	Ballet	9	9	ns	ns	ns	ns	NS	PAIS OT	Open PL
S8	1998	Sammarco	Ballet	13	14	13	0	ns	ns	20	FHL	Open PM
S9	1999	Spicer & Howse	Ballet, stud. & prof.	39	60	30	9	ns	ns	12-48	PAIS	Open PM
S10	2002	Labs	Mixed professional:	24	24	20	4	ns	ns	22	18 PAIS,	Open PM
			14 ballet, 7 revue, 3 jazz								6 combined	
S11	2007	Tey (S11)	Ballet professional	3	4	3	0	ns	ns	20	PAIS	Endo
S12	2014	Vila (S12)	Ballet professional	6	6	4	2	ns	ns	25	5 PAIS, 1 combined	Endo
S13	2015	Coetzee	NS	37	44	32	5	ns	ns	NS	PAIS OT	Open PM 36
												Open PL 8
S14	2016	Heyer & Rose	Ballet 36, modern 3, salsa 1	38	40	37	1	20	20	19,2	23 PAIS, 17 combined	Open PM
			38 (pre-) prof, 2 amateurs								FHL (triggering)	
C1a	2013	Guo (C1)	NS	5	5	ns	ns	ns	ns	NS	PAIS OT	Open PL
C1b			NS	2	2	ns	ns	ns	ns	NS	PAIS OT	Endo
C2a	2016	Ballal (C2)	Professional ballet	22	22	13	9	ns	ns	17,6	9 PAIS, 13 combined	Open NS
C2b			Professional ballet	13	13	7	6	ns	ns	20,4	11 PAIS, 2 combined	Endo

Nr	Year	Author	Type of Dance	Dancers	Ankles	F	M	R	L	Age	Pathology	Technique
			Level of participation								(number of ankles)	
	Total (excl. Thomasen):		Ballet: 245	308	355	218	62	64	67	21,3	PAIS: 243	PM: 255
			Modern-jazz: 13	Open 284	Open 330	78%	22%	49%	51%	Open 21,1	FHL: 38	PL: 53
			Revue: 7, salsa: 1	Endo 24	Endo 25	ns:	28	ns:	224	Endo 21,6	Mixed: 74	Open NS: 22
			NS: 44 'dancers'									Endo: 25

AOFAS: score of the American Orthopaedic Foot & Ankle Society; F: female; FFI: Foot Function Index; FHL: flexor hallucis longus tendinopathy; FU: follow-up; funct.: functional, using 'return to dance'; M: male; NS: not specified; PL: open via posterolateral approach; PM: open via posteromedial approach; OT: os trigonum; PAIS: posterior ankle impingement syndrome; PP: hypertrophic posterior process of talus; Qual: qualitative, e.g. using anchor questions;
Quant: quantitative, using scoring systems, e.g. AOFAS; RAND: Veterans RAND 12 Item Health Survey Mental and Physical Health; RtD: Return to Dance; VAS: visual analogue scale.
Age: in case of more than one patient the average age is taken. The total age is the average age of all dancers in all case reports, series and cohort studies, as far as specified (N=175). It is the same for open and endo.
† nrs a, b and c: since our search did not find Thomasen's book, we do not include his three case series (all open technique, 69 dancers, 72 ankles; see introduction and discussion), but we discuss them and do show them in this table 6, numbered a,b and c.
†† Dancers: the total number of dancers seen with the diagnosis (the number of operated dancers is given in brackets).

S6 Hamilton 1996: the 'Return to Dance' data indicate return to full performance and may not be representative, since they include amateur dancers and an outlier (one dancer who needed an additional operation after a year and finally had an excellent result). In an attempt to correct this the first author contacted dr.Hamilton, ...

Table 6: continued

Table 6 continued

Nr	FU months	Score	Result	Return to Dance (RtD) or previous level of participation
a	NS	Qual	33 painfree	NS
b	NS	Qual	All good / perfect	NS
c	NS	Qual	All but one symptom-free	NS
S1	NS	Qual & Funct	15 good, 1 fair, 1 lost	12-32 weeks
S2	84	Qual & Funct	All good	Mean 10 weeks (range 4-20)
S3	22	Funct	All but one relieved	Mean 7 weeks (range 5-10)
S4	28	Qual & Funct	8 still had occasional discomfort	Mean 12 weeks
S5	78	Qual & Funct	all patients noted improvement	Mean 20 weeks (range 8-36)
S6	84	Qual & Funct	23 excellent, 7 good, 6 fair, 4 poor, 1 initially poor, but excellent after reoperation (scored as excellent)	Mean 25 weeks (range 6-96) (S6)
S7	NS	Qual & Funct	All dancers asymptomatic	Within weeks
S8	19	Qual & Funct	13/14 excellent	12 weeks
S9	40	Qual & Funct	Overall 74% good & excellent	11 weeks
S10	26	Quant (Kitaoka) postop only	Very good 13 (54%), good 5 (21%), satisfactory 5 (21%), poor 1 (4%)	NS
S11	36	Quant (AOFAS) & Funct	AOFAS van 85 naar 100	Excluded (S11)
S12	28	Quant (AOFAS) & Funct	AOFAS van 50 naar 97	10 weeks (range 7-13) (S12)
S13	46	Quant (RAND, FFI, VAS) & qual (patient satisfaction)	RAND same, FFI 126 -> 79, VAS 6 -> 1,2. At 2 years: good and excellent 96%	NS
S14	48	Quant (VAS pre- & postop), qual (anchor questions) & funct	VAS 7,7 -> 0,6; all improved plantarflexion ROM, all 17 FHL relief; 95% success, 100% recommend	RtD: 7,8 weeks (range 3-20), RtD (painfree): 17,7 weeks (range 6-52 weeks)
C1a	48	AOFAS, VAS, Qual., Funct	NS (C1) postop. AOFAS > 90; VAS: 1,25	Mean 16 weeks (range 8-24)
C1b	31	AOFAS, VAS, Qual., Funct	NS (C1) postop. AOFAS > 93; VAS: 0,8	Mean 7 weeks (range 6-8)
C2a	12	Functional	All patients were asymptomatic with regard to their ankle at the final follow-up visit (12 months)	Mean 14.9, range 9 to 20 weeks
C2b	12	Functional		Mean 9.8; range 9 to 20 weeks

Nr	FU	Overall Scoring	Overall results (see also table 3)	Overall Return to Dance or previous level of participation
	42	Qualitative 12	Excellent 68%, good: 21%, fair 7%, poor 4%	Average RtD (Hamilton S6 excluded)
	(range 12-84)	Functional 16		11,2 weeks (range: 4-36 wks) (n = 212 ankles)
	NS 2 case series	Quantitative 9 (since 2002)		Average RtD (all series, Hamilton included)
				13,4 weeks (range: 4-96 wks) (n = 253 ankles)
		Open: in 27 ankles of 27 dancers of two cohort studies (Guo 5, Ballal/Roche 22), all PAIS:		mean open: 15,1 weeks (n = 27)
		Endo: in 15 ankles of dancers of two cohort studies (Guo 2, Ballal/Roche 13), all PAIS:		mean endo: 9,4 weeks (n = 15)

... but the original data were not available anymore. That is why we decided to exclude his 1996 findings from the 'Average RtD (Hamilton (S6) excluded)'. In 'Average RtD (all series)' his 1996 findings are included to demonstrate the negative impact.
S11 Tey: unfortunately the return to dance data in this (endoscopic) case series of three dancers were unreliable, since the authors combined the data of sports and dance: "All the patients (including dance and sports!) were able to return to full performance without restriction at an average of 3 months'. Since this could not be traced, neither in the full text, nor in their table, these data were excluded.
S12 Vila: in full text 11 dancers, yet their Table 1 lists 6 dancers (4 F, 2 M, average age: 25). Following the data in their Table 1: the "recovery time for practice activity at the same level than before injury" for the 6 dancers is: 2,5 months, range: 1,8-3,2 months.
S14 Heyer: Average time to return to dance was 7.9 weeks, and time to pain-free dance was 17.7 weeks. We decided to use their 'Average Return to dance' (7,9 weeks) for our calculation.
C1 Guo: Postoperative score only, dance and sports mixed: the difference in postoperative score between open and endo was statistically not significant.
C2 Ballal: Groups not comparable: C2a Younger national ballet school dancers; C2b Older seasoned professional dancers. Open group considerably younger and different rehabilitation. 1 patient (7.7%) in endoscopic group and 3 (13.6%) in open group had concurrent lateral ligament reconstruction. 13 patients (59.1%) in open group had FHL tendon decompression compared with 2 patients (15.4%) in endoscopic group.

Table 7: Complications in 355 ankles (308 dancers) *

Open PL (n=47)	Open PM (n=184)	Open NS (n=99)	Endo (n=25)
6 (12,8%)	8 (4,%)	7 (7,1%)	1 (4%)
Open total (n = 330 ankles)			Endo (n = 25 ankles)
21 (6,4%)			1 (4%)
All complications in all operations (N = 355 ankles)			
22 (6,2%)			
More serious complications in all operations (n = 355)			
3 (0,8%) in all (n = 355)		3 (1%) in open only (n = 330)	

Procedure: open NS/PL/PM, open not specified (NS); open via posterolateral (PL) or open via posteromedial (PM) approach; * These numbers include four case series (52 operations in 44 dancers) in which we assumed there were no complications, however this was not specified.

Epidemiology and natural history of PAIS and/or FHL tendinopathy in dancers: We identified only one paper addressing the epidemiology and natural history of PAIS in dancers.[59] The authors observed 186 young trainee ballet dancers during one year, and found that 12/186 (6.5%) suffered from posterior ankle pain, of which 6/12 (50%) had an os trigonum. All 12 ballet dancers were treated non-operatively, and 9/12 (75%), including all six soft tissue impingement cases, had good results. In 3/12 (25%) cases after 1-4 months of unsuccessful conservative treatment, good results were obtained through surgical excision of the accessory ossicle.

Conservative treatment of PAIS and/or FHL tendinopathy in dancers: Six publications (three case reports, two case series, and one systematic review) described the results of conservative treatment of PAIS and/or FHL tendinopathy in 33 cases involving 28 dancers.[12;59;63;72;80;82] The quality and level of evidence of these publications was low, except for the systematic review.[80] See Table 8.

Table 8: Conservative treatment of PAIS and / or FHL in dancers (three case reports, two case series, one syst.review)

Table 8: Conservative treatment of PAIS and / or FHL in dancers (3 case reports, 2 case series, 1 syst.review)

Nr.	Year	Author	Type of study	Type of dance and level of participation	Dancers and/or ankles	Age	PAIS or FHL	Pathology	Successful cons.treatment	Return to Dance or previous level of participation
1	2006	Berglund	Case report	Female preprofessional modern dance-school student	1	17	1 FHL	FHL tendinopathy: 1	Yes	After 6 weeks symptomfree and participating in all dance activities
2	2008	Biggs	Case report	female ballet dancer	1	17	1 OT	Os trigonum: 1	No	Awaiting surgery
3	2010	Porter	Case report	female ballet dancer	1	17	1 FHL	FHL tendinopathy 1	No	Successful surgery
4	1998	Sammarco	Case series	female ballet dancers	13 dancers, 18 ankles	20	18 FHL	FHL 18	yes in 4 (22%) cases, no in 14 cases (78%)	14 cases surgery, 13 successful
5	2009	Albisetti	Case series	young trainee ballet dancers	12 dancers in an academic year of 186 dancers	14	12 PAIS	PAIS (soft tissue): 6, bony impingement (os trigonum): 6	yes in 9 (75%), no in 3 (25%) OT cases	9 'did well', 3 OT cases had successful surgery
6	2015	Ribbans	Syst.review	NA	NA	NA	NA	NA	NA	NA
			Average or total:	Ballet: 27, modern dance 1	28 dancers with 33 cases of PAIS or FHL	17	20 FHL, 13 PAIS (6 soft tissue, 7 OT)	See text	See text	

FHL, flexor hallucis longus tendinopathy; NA, not applicable; OT, os trigonum; PAIS, posterior ankle impingement syndrome.

Discussion

We are pleased to have found 27 publications describing the results of operative treatment of PAIS and FHL tendinopathy in dancers only, of which this is, to the best of our knowledge, the first systematic review. In these publications we found the results of 376 operations, with 89% good and excellent results, an average return to dance of 11.2 weeks, and 0.8% serious complications. Preliminary evidence shows that dancers operated on for FHL tendinopathy might recover significantly slower.

Unfortunately, the level of evidence of these studies, like that found in sports in general,[80] is confined to level four (non-comparative retrospective case series) and five (case reports and expert opinions). Two relatively recent (2014 and 2016) cohort studies retrospectively compare the open technique versus endoscopic surgical treatment for PAIS in dancers. Both studies are of low quality with regard to the comparative side and do not meet the criteria for level three. One is downgraded two levels and to be considered level five, given the low number of dancers, insufficient demographic data, missing description of the type of dance, level of participation, and return to dance, and mixed data of dance and sports.[78] The other retrospectively studied two case series of high-level ballet dancers, which also were briefly described in an expert opinion review in 2013.[79] The type of operation in this latter study's open group was not specified. Since the groups were not comparable, it is downgraded one level to level four.[77]

A limitation of our review is that it includes only the systematically searchable and hence for the medical profession readily accessible scientific literature, and has no additional records identified through other sources, like the reference lists of identified studies (except that this review included additional searches in the French medical literature, using Science Direct). We do not think this would alter the results, however, and feel it is of paramount importance to underline the scarcity and poor levels of evidence in the literature for these injuries in dancers, and have therefore dedicated most of the discussion to this.

Due to the low quality of the level of evidence of the available literature, the paucity of recent studies, and the low number of dancers treated endoscopically, the scientific evidence for the results of treatment of PAIS and/or FHL tendinopathy in dancers is currently imprecise and weak, and this limits translation to the individual patient. In particular, we identified the following limitations:

1 Type of dance and level of participation: These factors are poorly described and rarely specified, whereas they have an enormous impact on the levels of demands, required of the dancer, adding to the problem of evaluating outcome.

2 Inconsistent outcome reporting: A lack of consistent outcome reporting further complicates comparison. This makes it impossible to formulate firm conclusions and recommendations. Since 2002 quantitative pre- and post-operative outcome-scoring have become more common. Unfortunately, in our personal experience, the AOFAS is not sufficiently discriminative in dancers, because it has a "ceiling effect"; i.e., given the high demands of dance the AOFAS score may be 90/100 or more in spite of the fact that the dancer is unable to dance without limitations.[83;84] To date, in this search we found no evidence of use of a dance-specific outcome score like the Dance Functional Outcome System (DFOS),[85] in spite of the fact that this would be the preferred outcome measure. The DFOS focuses on dance-specific, functional movements, like relevé, that are unaddressed in other sports or generic questionnaires and provides a tool for investigating clinical efficacy in dance medicine.[86] We recommend that this tool be validated and used pre- and post-operatively at standardized intervals in combination with graded dance-specific rehabilitation.[87]
3 Low numbers of endoscopically treated dancers: Only 30 dancers (32 ankles) were treated endoscopically, compared to open: 294 dancers (344 ankles). The endo group forms only 9% of the total number of 324 operated dancers (376 ankles) in the literature to date, making conclusions regarding the preferred surgical procedure impossible.
4 Lack of clinical studies: As the research presented here makes abundantly clear, there is a paucity of clinical studies of PAIS and FHL tendinopathy, especially with regard to the epidemiology, natural history, and outcomes of conservative treatment in dancers.
5 Return to dance: This is a good functional outcome measure, provided the type of dance, level of participation, and timing of return to dance are described and differentiated, which rarely is the case. One of the flaws of all studies on PAIS and/or FHL tendinopathy in dancers is the poor, varying, or completely missing definition of return to dance. In ballet, for example, return to dance can have many different meanings, e.g., starting exercises with support (at the barre), resuming daily training in the group or company (class), or full performance (on pointe)[5] completely pain-free.[68] Furthermore, performances have varying levels of demand, the easiest being essentially pantomime, and the most demanding roles that include heavy dancing on pointe. Due to all these factors we found enormous differences in return to dance, varying from 4 to 36 weeks (not taking into account an "outlier" of 96 weeks).[5]

If "return to dance" is used as an outcome measure we recommend to differentiate, define, and preferably standardize the levels of return in a way that is universally applicable to all dance forms (not only ballet), and in accordance with the principles of graded and "preventive" rehabilitation.[87]

That is, the dancer is able to engage in the following dance activities:

1. *No impact:* fully assisted weight bearing ('barre'), including relevé and demi-plié, without turns or jumps;
2. *Low impact*: unassisted weight bearing, including explosive relevé and small jumps and turns;
3. *High impact:* big jumps and running
4. *Full dance performance*: including all requirements of the type of dance and level of participation.

Open operation or endoscopic: Given the differences in type of dance and level of participation, the variety in outcome measures of the found publications, and the low numbers of endoscopically treated dancers, it seems virtually impossible to compare the results of open surgery with endoscopic operations.

A small cohort study published in 2016 is the first to compare results of open surgery with the endoscopic technique specifically in dancers.[77] Unfortunately, the two groups are incomparable and their conclusion, that the endoscopic technique is superior to the open technique, is not justified: the larger proportion of FHL tendinopathy patients delays return to dance in their open group, as found in our review, whereas the larger proportion of professionals may make the surgical procedure more successful in their endo group. Besides, the larger proportion of concurrent lateral ligament reconstructions in their open group will have caused further delay in return to dance. From a return-to-dance point of view, it seems that the dancers in several open case series[20,30,38] return to dance faster than, or as fast as, after an endoscopic operation, suggesting that the open operation is at least equally attractive and perhaps even preferable (see Table 6). Looking at quantitative and qualitative results of both techniques, we found no evidence supporting superior long-term results of one technique over the other.

FHL tendinopathy: Dancers with isolated FHL tendinopathy (without PAIS), operated via an open posteromedial approach, returned to dance slower (16 weeks) than average (11 weeks: see Table 4).[69;72] However, the literature is not unequivocal on this subject, since dancers with a combination of PAIS and FHL tendinopathy, operated via the same open posteromedial approach, were the fastest (seven weeks) to return to (unspecified) dance.[68;76] But if "unspecified" is changed to "pain-free" return to dance the time doubles (14 weeks). These findings suggest that FHL tendinopathy with and without PAIS may be different injuries. So FHL injuries are challenging. In his proof of concept case report van Dijk describes one ballerina (two ankles) treated endoscopically for combined PAIS and FHL tendinopathy who had an excellent result and return to dance in eight weeks.[15] Hypothetically, dancers with FHL injuries may benefit most from the new endoscopic technique, given the good endoscopic

judgment of FHL pathology and the amount of dissection around the neurovascular bundle required in the open posteromedial approach. Release of the FHL tendon sheath can be done safely endoscopically,[88] provided the surgeon stays laterally of the tendon, "on the bone," but endoscopic FHL tendon repair is (as yet) impossible.

Age: The average age of all operated dancers in all case reports, case series, and in the two cohort studies (age specified in 175 dancers) was 21 years. There was no difference in age between the open (age specified in 150 dancers) and endoscopic (specified in 25 dancers) groups. PAIS and FHL tendinopathy are injuries that generally occur early in a dancer's career, and, if needed, operative treatment is a reasonably safe and successful procedure. This indicates that the fact that these ankle injuries are less common in older dancers may be explained by successful surgical treatment at a younger age, and not only by a "healthy worker effect". [1]

Complications: The general complication rates in sports, respectively 3.9% for open medial, 12.7% for open lateral, and 4.8% for arthro-endocopic surgery,[80] are comparable to the rates we calculated in dancers, respectively 2.8% for open posteromedial and 12.8% for open posterolateral, 4% for the endoscopic technique. In sports the complication rate of the endoscopic technique is 3.8% - 4.2%, with 1.8% requiring ongoing or operative intervention.[13,79] Surgical treatment of PAIS and FHL tendinopathy in dancers generates less than 1% serious complications.

Conservative treatment: We found no reliable results of conservative treatment of PAIS and FHL tendinopathy in dancers. In several publications that present the results of surgical treatment conservative treatment is described as well. Unfortunately these studies do not represent the results of conservative management, since "failed conservative treatment" is a prerequisite of the indication for surgery, and forms selection bias. Successful conservatively managed cases may be underreported.[12] Based on only the two case series we found it might be speculated that conservative treatment is successful in 75% of PAIS cases in dancers, being twice as successful in soft tissue impingement as in symptomatic os trigonum,[59] and in 22% of FHL tendinopathy in dancers.[72] Unfortunately, too little information has been made available to allow for any evidence-based recommendations to be made regarding the results of conservative treatment or the choice of non-surgical modalities.[80]

Natural history: The natural history of PAIS and FHL tendinopathy remains unknown. Based on one level 4 case series only, the prevalence of posterior ankle pain in young trainee ballet dancers is 6.5% (12/186 dancers).[59] Of course it is not realistic to extrapolate these data to dancers in general.

Dance and sports in general: Due to the fact that the systematic review by Ribbans et al. in 2015 assessed the efficacy of management of PAIS in sports in general, their findings are complementary to ours.[80] Since we studied dance specifically, and our search extended two and a half years longer, there was only 59% overlap between their reference list and ours. However, their references included two articles about dancers that were not found in our search because the various search terms we used concerning dance were mentioned in the full text only. In one article an 11-year old "dancing and swimming" girl is mentioned in a table: "surgical excision of a symptomatic os trigonum by medial approach bilaterally resulted in pain relief" and "resumption of sports activities at M3," without any further details.[89] Because of this unspecified remark we did not include it in our review. The second article was a review that mentioned a dancer in a case report, but this case report was already included in our study.[15;90] Ribbans et al. identified 827 surgeries for PAIS and FHL tendinopathy, of which 340 (41%) were open and 487 (59%) arthroscopic/endoscopic procedures. Overall, dance represented the most commonly reported recreational activity, with 62%. Dance especially dominated the open procedures (85%), whereas soccer (45%) was the most common activity treated endoscopically. Interestingly, in the earlier literature on open operations the type of sport was specified in 298 (88%) of the entries, of which 252 (85%) were dancers, which constituted 74% of the total procedures. In the more recent literature on endoscopic surgical treatment the type of sport was specified in 147 (30%) cases, of which 26 (18%) were dancers, which accounted for only 5% of the total number of cases. In our opinion this is due to the fact that in the endoscopic publications the emphasis was more on the new technique and its implications than on the demands and type of activity of the patients, and secondly that many fewer dancers were treated in the endoscopic group than in the open group.

The overall analysis of Ribbans et al. revealed osseous involvement of various forms in 81% of cases, and FHL tendinopathy involvement in 35% of cases. The incidence of FHL tendinopathy involvement was more often reported in dance (52%) than in soccer (20%), indicating an important difference between the two activities.

Conclusions

1. The quality and level of evidence in the clinical studies of PAIS and/or FHL tendinopathy in dancers is confined to levels four and five;
2. Operative treatment of PAIS and/or FHL tendinopathy in dancers is unequivocally successful (89% good and excellent results), has an average return to dance in 11 weeks, and has less than 1% serious complications, regardless of the surgical technique used.
3. Operative treatment of isolated FHL tendinopathy in dancers seems to have the longest return to dance time: 16 weeks.

4. We found similar results in open and endoscopic operations, both in terms of return to dance times and end result.
5. There is a lack of studies on the epidemiology, natural history, and outcomes of conservative treatment for these conditions in dancers.
6. Preliminary results in only six studies of low quality suggest a 75% success of conservative treatment (including injections) in PAIS generally, being most successful in soft tissue impingement, 50% successful in case of asymptomatic os trigonum,[59] and least successful in case of FHL tendinopathy.[72]
7. The average age of patients operated for PAIS and/or FHL tendinopathy is 21 years, so the operation tends to occur early in a dancer's career.

Recommendations

If conservative treatment fails, dancers with PAIS and/or FHL tendinopathy may confidently undertake surgical management, given the good outcome and low risk.

However, since isolated PAIS, PAIS combined with FHL tendinopathy, and isolated FHL injuries seem to be different pathological entities, more research is needed to determine in which cases early operative management should be considered or avoided, taking into account demography, dance type, and level of participation. The same applies to defining the place of endoscopic surgery in dancers, and to being able better to predict which pathology is likely to produce worse outcomes or delay in return to dance.

In general large, preferably prospective, clinical (comparative) cohort studies are recommended, with a good description of the demography, type of dance, and level of participation involved, as well as the use of a validated functional, dance-specific outcome score, and a preferably standardized definition and differentiation of the levels of "return to dance," both pre- and post-treatment.

A prospective, randomized, controlled design should be used to compare different conservative and operative treatment options.

Given the lack of publications on the outcomes of conservative treatment, any clinical studies on this subject are more than welcome, to be able to predict in which cases conservative measures are most likely to be beneficial, and which treatment modalities will be most effective.

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Chapter 8

Posterior Ankle Impingement Syndrome and Flexor Hallucis Longus Tendinopathy in dancers: results of open surgery

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8 Posterior Ankle Impingement Syndrome and Flexor Hallucis Longus Tendinopathy in dancers: results of open surgery

Abstract

Posterior ankle impingement syndrome (PAIS), the result of posterolateral soft tissue and/or bony impingement of the ankle, and tendinopathy of the flexor hallucis longus (FHL tendinopathy) in the ankle, are common in dancers. If conservative treatment of these conditions fails to produce adequate results, surgical intervention might be necessary. However, outcomes of treatment by open surgery for these diagnoses have been described only in small series of dancers. For this study data were extracted from clinical files and operative reports of an orthopaedic surgery clinic specialized in dance medicine. Prior to October 2016, 148 patients (82.1% female, median age 19 years) underwent 190 open procedures, 57 (30%) for FHL, 83 (43.7%) for PAIS, and 50 (26.3%) for a combination thereof. In 90.8% of cases patients reported a "better" or "much better" post-operative outcome. There were only minor, transient complications that neither required re-intervention nor influenced outcome. Patients were followed-up for a median of 157 days (interquartile range 91-245). Those operated on by a lateral approach were discharged from follow-up earlier (lateral 113 days vs 190 for medial approach, $p = 0.005$), but there was no difference of outcome at discharge. It is concluded that the open surgical treatment of PAIS and FHL tendinopathy in dancers has a high success rate, and can be considered a successful standard operative procedure. More detailed information is needed about dance-specific outcomes and the early post-operative course of rehabilitation.

Figure 1: On pointe

Figure 2: Tendu

Figure 3: Relevé or demi-pointe

Introduction

Dancers are athletes who put a unique strain on their musculoskeletal system. One of the special requirements is the extreme range of motion demanded of the foot and ankle complex. Dancing on pointe ("full-pointe" or "sur-les-pointes," Figure 1), tendu (Figure 2), and relevé (or "demi-pointe," Figure 3) are ankle positions that are dance-specific and require maximal plantar flexion of the talo-crural joint. The forceful plantar flexion of the foot-ankle-complex that these positions have in common produces compression between the calcaneus and the posterior aspect of the tibia, and in these positions the flexor hallucis longus (FHL) is an important stabilizer of the foot.

Both demi-plié (Figure 4) and grand-plié (Figure 5) are also very common in dance and require weight-bearing maximal dorsiflexion of the talo-crural joint, stretching especially the posteriorly located FHL tendon, and causing "wringing out" of its blood supply, which is already at risk due to an avascular zone posteriorly of the talus.[1] Furthermore, in grand-plié a distally inserting FHL muscle belly is pulled down into the FHL tunnel ("cork in bottle phenomenon"[2,3]) causing entrapment, especially if there is limited space due to a bony impediment.[4,5]

Posterior ankle impingement syndrome (PAIS), or "dancer's heel," and tendinopathy of the flexor hallucis longus (FHL tendinopathy), or "dancer's tendinitis," are common in dancers. PAIS is an acquired problem related to relevé and especially found in dancers who do pointe work. Both relevé and the en pointe position require stretching and training over many years to enable

Figure 4: Demi-plié

Figure 5: Grand plié

a dancer to achieve this maximum ankle excursion and to allow the talus to glide under the dome of the tibia in close proximity of the calcaneus. Symptoms of bony impingement in PAIS are a painful relevé and pain postero-laterally as an os trigonum (Figures 6-7) or hypertrophic posterior process of the talus gets impinged between the tibia and the calcaneus.

Figure 6: Radiograph on relevé: os trigonum (Shepherd's fracture) behind the talus gets impinged between the tibia and the calcaneus

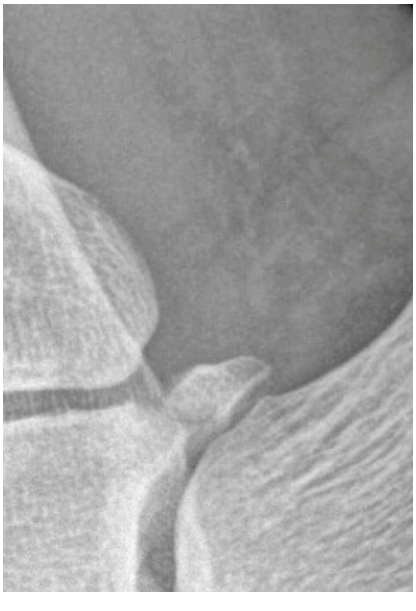

Figure 7: Same as Figure 6; close-up of os trigonum (Shepherd's fracture) in the center of the picture

Diagnostic tests that are commonly used for PAIS are the "plantar flexion test," in which repetitive, quick passive hyper-plantar flexion movements are performed by the examiner,[2,6] or the "ankle McMurray test," in which passive plantar flexion is performed slowly by the examiner, making a rotating movement with the foot from eversion to inversion (and vice versa) while at the same time giving upward compression on the calcaneus. These tests are generally accepted, but not yet validated.[7]

For reasons not fully understood, PAIS often coincides with FHL tendinopathy. Tendinopathy of the FHL is characterized by pain posteriorly and plantarly of the medial malleolus with plié, as the tendon makes an acute angle posteriorly of the talus and slides in an often narrowed and irritated sheath toward the sustentaculum tali. Diagnosis is made when the typical pain is elicited by pressure on the entrance of the FHL tunnel posteriorly and distally from the medial malleolus. In case of a "functional hallux rigidus" the typical pain will be elicited by compressing the FHL tunnel and at the same time forcing the hallux and the ankle into maximum dorsiflexion; this pulls a distally inserting FHL muscle belly down into the FHL tendon tunnel ("like a cork in a bottle").[2,8] The FHL tendon itself may demonstrate fusiform thickening or central necrosis, and in more severe instances calcific nodules or partial degenerative tears in the tendon may lead to triggering of the hallux.[2,9-11] X-ray examination of the foot and ankle complex can be obtained to study whether a bony impediment is present. MRI is only indicated when no conclusive diagnosis can be reached based on history and physical examination.

Although evidence is lacking, it is assumed that in most cases, especially in soft tissue impingement, the symptoms of PAIS and FHL resolve with conservative treatment such as corrected technique, physiotherapy, home exercises, NSAIDs, and corticosteroid injections.[12] However, in some cases there is an etiology that limits the dancer's range of motion and fails to improve. These refractory cases may be due to FHL tendinopathy, bony impingement, or a combination thereof. The types of bony impingement are an os trigonum, Stieda's process (Christian Hermann Ludwig Stieda, German anatomist, 1837-1918), or Shepherd's fracture (Francis J. Shepherd, Canadian surgeon, 1851-1929: Figures 6-7).[13-15] When conservative care fails, surgery is necessary. The surgical approach differs based on the pathology that is causing the impingement.

Open surgical treatment of PAIS in dancers was described for the first time in 1972,[16] of FHL tendinopathy in 1976,[17,18] and of trigger toe in 1979.[11] Isolated PAIS due to an os trigonum or hypertrophic posterior process of the talus in dancers is surgically approached laterally. An incision is made posteriorly of the lateral malleolus, and after identification and protection of

the sural nerve capsulotomy is performed to find the os trigonum or hypertrophic posterior process, which is subsequently removed.

FHL tendinopathy in dancers is surgically approached medially. The incision is made posterior to the medial malleolus, after which the neurovascular bundle is freed and retracted posteriorly to identify the tunnel of the FHL, which is subsequently released. Also in cases of FHL tendinopathy combined with PAIS a medial approach is used, the bony impediment is found deep of the FHL tendon, and subsequently removed (see Figures 8-13). Post-operatively the dancer-patient is usually supervised by a specialized physiotherapist.

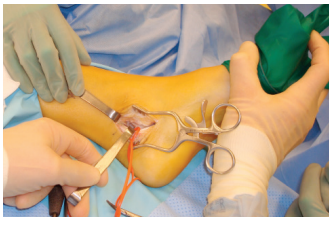

Figure 8: Posteromedial side of the left ankle. Overview to show the position of the left foot.

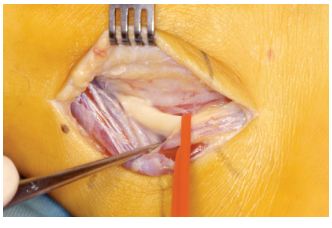

Figure 9: Posteromedial side of the left ankle. The neurovascular bundle is retracted with a red vessel loop, the forceps is inserted between the posterior tibial artery and veins (below the forceps) and the tibial nerve, which is the size of a pencil. The muscle belly in the lower aspect of the wound is a rare anatomical variation: an accessory soleus muscle

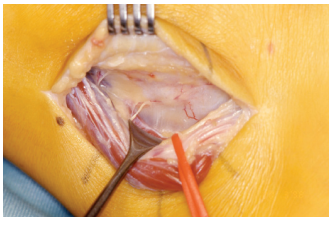

Figure 10: Posteromedial side of the left ankle. The neurovascular bundle retracted with a hook. Deep in the wound the FHL tendon-sheath is visible.

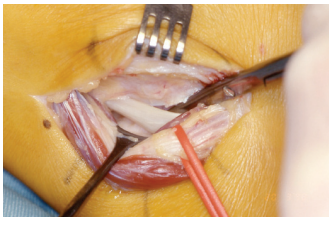

Figure 11: Posteromedial side of the left ankle. After opening its sheath the FHL tendon is presented in the wound

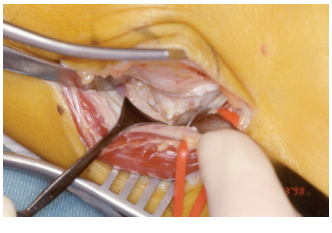

Figure 12: Posteromedial side of the left ankle. A spiky Stieda's process is visible deep of the FHL tendon, above the two hooks

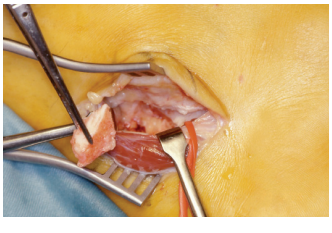

Figure 13: Posteromedial side of the left ankle. The triangular bony fragment ("os trigonum") is chiseled off of the posterior aspect of the talus.

In the literature 25 articles can be found that have studied the surgical treatment of PAIS and FHL tendinopathy in a total of 308 dancers (355 ankles).[12] The largest case series of operative treatment of PAIS describes the results in 39 dancers (60 ankles).[19]
This study aims to describe retrospectively the outcome of open operative treatment of PAIS and FHL tendinopathy in a large cohort of dancers, regarding results and post-operative morbidity, to establish a benchmark for future reference. To our knowledge this is the largest cohort of consecutive cases of PAIS and FHL tendinopathy in dancers operated on by a single orthopaedic surgeon.

Methods

Patient population: Consecutive patients operated on for PAIS and FHL tendinopathy were identified using hospital records of ankle surgeries performed by the first author between 1989 and October 2016. Matching patient files were then retrieved to filter surgeries performed in dancers only. Endoscopic surgeries were excluded and described in a separate article.[20]
Two ankles in the same patient were described and analysed as two separate procedures. Any secondary procedure due to failure of a previous procedure was excluded, but, if the first surgery was performed by the first author, the second surgery was described separately.
The study was approved by the medical ethics board of the hospital and conducted in accordance with the declaration of Helsinki.

Determination of patient characteristics: Patient characteristics, signs and symptoms, and follow-up were extracted from the clinical files. Patients were considered professional dancers if they were or had been enrolled in a vocational dance academy. Primary dance style was defined by the phrasing of the patient.

Operative characteristics: were derived from operative reports. Duration of the procedure was divided by two in cases of bilateral surgery on the same day. Patient characteristics and medical history were recorded at the initial presentation. Clinical findings were recorded at the appointment at which the decision for surgery was reached. All patients were operated on after they had failed at least six months of conservative treatment, including NSAIDs, orthotics, and physiotherapy, usually prescribed by the referring physician, otherwise started by the authors. Post-operatively the dancer-patient used a compression dressing for two days, and was allowed to bear weight as tolerated. When the intra-cutaneous sutures were removed after two weeks, vigorous mobilization of dorsiflexion and reconditioning were started, using a dance-specific, graded rehabilitation schedule, and usually supervised by a specialized physiotherapist.[21]

All symptoms that deviated from a normal course of rehabilitation and could be traced back during follow-up to the surgery were considered as complications. Follow-up time was defined as time to discharge from follow-up, and was measured in days.

Definition of outcome: Outcomes were scored at the day of discharge from follow-up. Post-operative success rate was defined by a patient's satisfaction score ranging from 1-5 (1, much worse; 2, worse; 3, the same; 4, better; 5, excellent) comparing pre- and post-operative situation at the date of discharge from follow-up. The scores were extracted independently from the clinical files by the second author.

Analyses: Differences between groups were calculated using chi-square tests for categorical variables. Survival analysis was performed using a Kaplan Meier curve with a log-rank test to look for a possible difference between patients with and without FHL tendinopathy. All analyses were performed using SPSS 22.0 (SPSS, IBM corp).

Results

Identification of procedures: In the hospital records 242 procedures for PAIS and/or FHL tendinopathy were found, affecting 193 patients. After exclusion of 52 procedures for various reasons, 190 procedures (148 patients) were included in the present study (Figure 14).

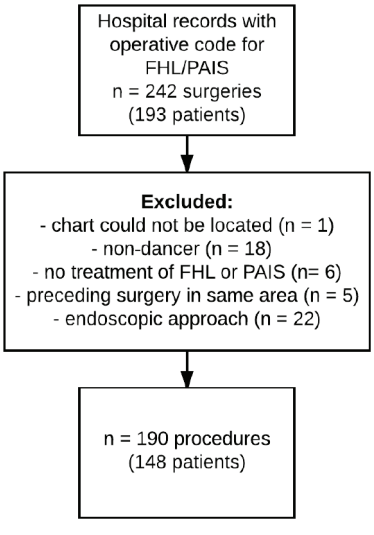

Figure 14: Flow diagram of patient inclusion

Population characteristics: The median age of the studied population was 19 years (IQR 16-22 years), and 82.1% of the patients were female. Most functioned on a professional level in one style or another of theatrical dance. All baseline characteristics can be found in Table 1.

Table 1: Baseline characteristics	Procedures (n=190)
Age in years median(IQR)	19 (16-22)
Female sex n(%)	156/190 (82.1)
BMI median (IQR)	20.5 (18.5-21.9)
Current smoker n (%)	26/160 (16.3)
Professional dancer n (%)	144/190 (75.8)
Age start dancing in years median (IQR)	6 (4-8)
Hours of dance a week median (IQR)	13.5 (6.5-20)
Primary dance style n (%)	
- Classical ballet	85/185 (45.9)
- Modern/jazz	64/185 (34.6)
- Show/musical	16/185 (8.6)
- Ballroom	14/185 (7.6)
- Other (folklore, urban)	6/185 (3.2)

BMI: body mass index, IQR: interquartile range. Categorical variables are displayed as numbers of total for which the information was available, with percentages in parentheses. Continuous variables are displayed as medians with interquartile ranges (IQR).

Signs and symptoms: Of the 190 procedures, 57 (30%) were performed for FHL tendinopathy, 83 (43.7%) for PAIS, and 50 (26.3%) for a combination of these. Patients with PAIS presented with pain in the posterolateral aspect of the ankle, whereas patients with FHL tendinopathy presented with pain postero-medially. Not surprisingly, patients with a mixed diagnosis displayed a mixture of symptoms (Table 2).

Surgical approach: In isolated cases of PAIS a lateral approach was used; in other cases a medial approach was used (Table 3). Median operating time per procedure was 34 minutes (IQR: 30-40) for the lateral approach and 44 minutes for the medial approach (IQR 35-55). Specific findings during the surgeries included three cases of a duplicate os trigonum and three cases of a tendon ganglion of the FHL. Furthermore, an accessory soleus muscle was seen in five cases (see figure 9). A muscle belly that extended distally and may thus give rise to the "cork in bottle" phenomenon was described in 77.7% of cases. Ten patients needed FHL tendon repair, seven of whom presented with a triggering hallux (see Figures 15-16).

Table 2: Signs and Symptoms	FHL tendinopathy n = 57	PAIS n = 83	Both n = 50
Preceding trauma n (%)	6/57 (10.5)	22/82 (26.8)	9/44 (20.5)
Provocation of complaints n (%)			
▪ demi-plié	16/22 (72.7)	20/27 (74.1)	15/19 (78.9)
▪ tendu/pointe work	33/33 (100)	63/64 (98.4)	28/32 (87.5)
Punctum maximum of pain n (%)			
▪ posteromedial	26/36 (72.2)	7/47 (14.9)	12/21 (57.1)
▪ posterolateral	4/36 (11.1)	36/47 (76.6)	5/21 (23.8)
▪ both	1/36 (2.8)	1/47 (2.1)	-
▪ elsewhere	5/36 (13.9)	3/47 (6.4)	4/21 (19.0)
Pain with n (%)			
▪ plantar flexion test	7/27 (25.9)	34/67 (50.7)	6/16 (37.5)
▪ ankle McMurray test	10/46 (21.7)	71/77 (92.2)	28/38 (73.7)
▪ applying pressure medially	53/54 (98.1)	30/78 (38.5)	38/45 (84.4)
▪ applying pressure laterally	18/43 (41.9)	76/78 (97.4)	27/41 (65.9)

Categorical variables are displayed as numbers of total for which the information was available, with percentages in parentheses.

Table 3: Operative characteristics	Medial approach n = 104 (%)	Lateral approach n = 86 (%)
Operation side:		
▪ right	51/104 (49.0)	43/86 (50.0)
▪ left	53/104 (51.0)	43/86 (50.0)
Bilateral surgery:		
▪ in one procedure	32/104 (30.8)	32/86 (37.2)
▪ in two procedures	23/104 (22.1)	6/86 (7.0)
Operation time in minutes (median, IQR)	44 (35-55)	34 (30-40)

Categorical variables are displayed as numbers of total for which the information was available, with percentages in parentheses. Continuous variables are displayed as medians, with interquartile ranges (IQR)

Outcome

Follow-up information was available for 185 of the 190 procedures (97.4%). In 168 cases (90.8%), patients described the post-operative result as "better" or "much better" when compared to the pre-operative situation (Table 4). When operative success was defined as

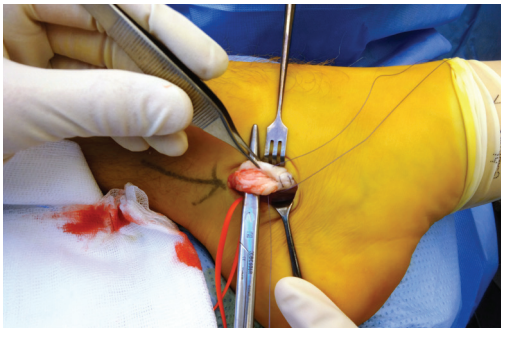

Figure 15: FHL tear

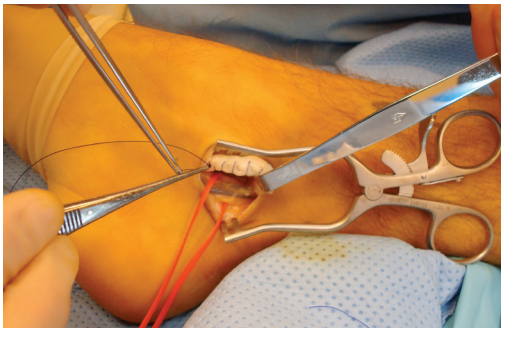

Figure 16: FHL tear sutured

"all patients that scored better or much better," reported smokers experienced less operative success (77% vs 94%, p = 0.005, data not shown). There were 24 minor transient complications (13%, Table 4), the presence of which neither required re-intervention nor influenced the post-operative results (90.6% success rate within patients without complication vs 91.7% success rate in patients with complication, p = 0.87). Smokers did not experience more wound infections when compared to non-smokers (3.8% vs 2.2% respectively, p = 0.63, data not shown). Return to dance was not systematically documented in the patient files. Patients visited the outpatient clinic according to protocol: two weeks, six weeks, three months, and half a year post-operatively or longer if needed. Median follow-up time was 157 days (IQR 91-245 days). Dancers operated via a lateral approach had a significantly shorter median follow-up time (lateral 113 days vs 190 for medial approach, p = 0.005, Figure 17). In spite of this shorter follow-up time there was no difference in end result between the lateral and medial approach (p = 0.24, data not shown). Operative tendon repair (see Figures 15-16) did not influence post-operative outcome (100% vs 90.1% operative success for tendon repair cases and non-tendon repair cases respectively, p = 0.30, data not shown).

Discussion

This study contains the world's largest consecutive case series of dancers surgically treated for PAIS and /or FHL tendinopathy by the traditional open operative method. We found a high success-rate (90.8%) for this operative method, with only minor complications that did not influence outcome during follow-up.

The success-rate described in the present study compares favorably with the literature to date, in which 89% good and excellent results, and 0.8% serious complications were reported. We found 13% minor transient complications in our cohort, of which none were serious.

Table 4: Surgical Outcome	Medial approach: n = 101 (%)	Lateral approach n = 84 (%)
General outcome		
▪ much worse	-	-
▪ worse	1/101 (1.0)	1/84 (1.2)
▪ same	8/101 (7.9)	7/84 (8.3)
▪ better	26/101 (25.7)	33/84 (39.3)
▪ much better	66/101 (65.3)	43/84 (51.2)
Complications	24/185 (13)	
▪ transient neurapraxia		
of which tibial nerve	6/101 (5.9)	-
of which sural nerve	-	9/84 (10.7)
▪ superficial wound infection	2/101 (2.0)	2/84 (2.4)
▪ posttraumatic dystrophy	2/101 (2.0)	-
▪ tarsal tunnel syndrome	1/101 (1.0)	-
▪ not otherwise specified	1/101 (1.0)	1/84 (1.2)
Median follow-up time in days (IQR) *	190 (122-298)	113 (74-192)

* defined as the time to discharge from follow-up. Categorical variables are displayed as numbers of total for which the information was available, with percentages in parentheses. Continuous variables are displayed as medians, with interquartile ranges (IQR).

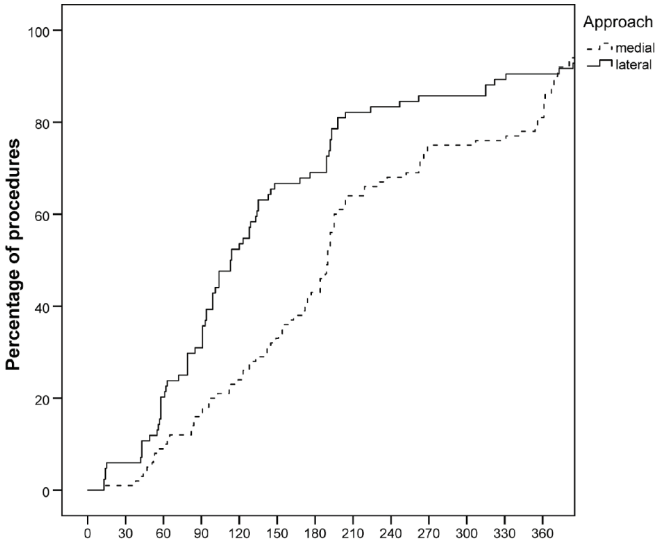

Figure 17: Kaplan Meier survival curve of follow-up time for lateral and medial approaches.
X axis cut off at 1 year post-operatively.

We described a total of 31 patients who underwent bilateral surgery with one procedure. We found these bilateral approaches to be well tolerated by the patients. Moreover, as rehabilitation time is an important factor to consider in professional dancers, this enabled the dancer to go through the negative effects of the surgery only once. Most patients were non-smokers. We found evidence for a negative effect of smoking in this cohort, whereas smoking was actively discouraged in all patients. This is not a surprising finding as smoking is a known cause of impaired wound healing. Furthermore, we found a difference in time to discharge from the outpatient clinic between patients operated on medially when compared to patients operated on laterally. Possible explanation for this is the larger amount of dissection (crossing more anatomical layers, like the ligamentum laciniatum and the tarsal tunnel) that is required to protect the neurovascular bundle in the open posteromedial approach as compared to the open postero-lateral approach. More dissection implies a larger subcutaneous wound, more recovery time, and more scar tissue.

Diagnosis of PAIS and FHL tendinopathy can usually be made based on simple physical signs and symptoms, complemented by X-ray examination for bony impingement. We found a pattern of postero-medially located signs and symptoms in FHL cases and postero-laterally located signs and symptoms for PAIS cases. Unfortunately, due to the retrospective nature of this study, the diagnostic accuracy of the different signs and symptoms could not be definitively determined. Based on the available information presented in this study, the ankle McMurray test may be more specific than the plantar flexion test for PAIS.
We identified two procedures that can be considered operative failures, as they exhibited worse complaints as compared to the pre-operative situation. The first case was a smoking 29-year old classical ballet student with FHL tendinopathy who for reasons unknown to the authors unfortunately did not benefit from the surgery and left the outpatient clinic dissatisfied. The second failure was a 23-year old modern/jazz student operated for bony impingement based on an enlarged posterior process with minor complaints of the medial aspect of the ankle at first presentation. This patient was operated with a lateral approach, resulting in operative failure because of persisting FHL complaints. After re-operation with FHL tendon release, she reported a result that was "much better" as compared to pre-operatively. This case can thus be considered initial misjudgement of the surgeon.

Including the case described above, three patients were operated on twice on the same ankle. The second re-intervention was in a 15-year old classical ballet student with a bony impingement based on an enlarged posterior process. She reported a "better" situation as compared to pre-operatively, but still was persistently symptomatic. X-ray examination

revealed that the removal of the hypertrophic posterior process had been insufficient. This patient was operated on again with good results. The third re-operation entailed an 11-year old show/musical dance student who was initially operated on because of FHL tendinopathy, with excellent results. A year later the patient presented with PAIS complaints based on a newly developed hypertrophic posterior process that had not been present on the earlier X-rays. This patient was operated on again, with excellent results. The ankle in question was the only one included twice in the study, as the re-operation was considered a new case based on a new diagnosis.

Limitations of this study are mainly due to its retrospective nature. Firstly, the surgical outcomes are scored based on description of the post-operative status in the patient files. This may lead to overestimation of positive results, as the surgeon could have highlighted positive results and ignored negative ones in his notes. However, as this study included all patients and the second author independently evaluated all patients, the influence of this potential source of bias are considered to be minor. Secondly, functional outcome in terms of range of motion and return to dance were not described systematically in all patients, and therefore could not be taken into account. Future studies should further clarify the course of rehabilitation, preferably in a prospective manner, focussing on the short-term and dance-specific results, as these are under reported in the literature.

Thirdly, long-term follow-up was unavailable in the current study, thereby prohibiting any conclusions on long-term outcomes and recurrent symptoms, especially in FHL patients. Fourthly, this cohort can be considered a tertiary referral clinic population, and therefore extrapolation to other clinics and surgeons should be approached with caution. The procedure was carried out on a regular basis by this surgeon, which could impel the success-rate and mask the fact that it is a delicate, minimally invasive procedure. A well placed one inch incision usually will do. Surgeons not performing this operation regularly may be tempted to make a larger incision and exposure, un-necessarily jeopardizing the end-result. However, the whole learning curve of this surgeon was encompassed in the results and we found no evidence for a time-dependent effect of the success-rate.

Finally, although the demands of plantar flexion of the foot and ankle complex can be considered highest in ballet when compared to other dance styles, the outcome can be considered representative for dancers in general, since most dance styles were represented in this cohort.

This retrospective cohort study confirms earlier outcomes in smaller series of a high success rate for the traditional open approach to PAIS and FHL surgery. Future studies, preferably with a prospective design, should systematically report on dance-specific functional outcomes with pre- and post-procedural pain scales to quantify results, and should include measures of short-term follow-up, as the post-operative morbidity in the short term is insufficiently studied.

Conclusion

The open surgical treatment of PAIS and FHL tendinopathy in dancers has a high success-rate, and can be considered a successful standard operative approach. More detailed information is needed about dance-specific outcomes and the early post-operative course.

Acknowledgement

We thank Han Haitjema for taking the photographs of the dancer (the second co-author. Figures 1-5).The operation photographs were taken by George Patho, hospital photographer of Haaglanden Medical Centre in The Hague. All photographs are published with permission of the dancers involved.

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Chapter 9

Operative treatment of Posterior Ankle Impingement Syndrome and Flexor Hallucis Longus Tendinopathy in dancers: open versus endoscopic approach

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* *Authors contributed equally*

Operative treatment of Posterior Ankle Impingement Syndrome and Flexor Hallucis Longus Tendinopathy in dancers: open versus endoscopic approach

9

Abstract

Posterior ankle impingement syndrome (PAIS) is a painful, usually limited plantar flexion of the ankle joint, due to soft tissue impingement or a bony impediment, often coinciding with tendinopathy of the flexor hallucis longus (FHL) behind the medial malleolus. In persistent complaints the bony impediment is removed, the tunnel of the FHL tendon is released, or a combination of both procedures has traditionally been performed by open surgery. In 2000 an endoscopic surgical technique for PAIS and FHL tendinopathy was introduced. To date there is no evidence of the superiority of one surgical technique over the other in dancers, both the open and the endoscopic approach giving up to 90% good and excellent long-term results. We compared the first 20 consecutive open procedures with the first 19 consecutive endoscopic procedures in dancers only, all operated by the same orthopaedic surgeon. The post-operative outcomes were reviewed by studying the patient files, clinical evaluation, AOFAS scoring, and we administered a dance-specific questionnaire. The results in the open group were: nine excellent, nine good, one moderate and one poor (90% excellent and good). In the endoscopic group: nine excellent, six good, three moderate, one poor (79% excellent and good). Both groups returned to dance (barre) at a median of eight weeks (IQR: 2). The direct post-operative morbidity in the endoscopic group was less favourable, mainly related to hematomas and an inflammatory response or deep scar tissue formation. There were no major complications requiring re-intervention. Although the two small groups of patients and the retrospective character of our descriptive study do not allow firm conclusions or statistical analysis of subgroups, in this study the open approach seems to be better than the endoscopic approach in the surgical treatment of PAIS and FHL tendinopathy in dancers.

Introduction

Posterior ankle impingement syndrome (PAIS) is a painful, usually limited plantar flexion of the ankle joint, due to posterior impingement of either soft tissue or a bony structure -- e.g., an os trigonum or large posterior process of the talus (Stieda's process) -- between the posterior distal end of the tibia (malleolus tertius) and the posterior tuberculum of the calcaneus (Figure 1). Relevé (Figure 2) and on pointe (Figure 3) both are dance specific movements, in which maximal (90°) plantar flexion of the ankle joint is required. Relevé is utilized in virtually all types of dance. Hence it comes as no surprise that PAIS is common in dancers, and is also known as "dancers' heel". The presenting complaint of PAIS in dancers is usually a limited and painful relevé, and (if applicable) pointe work.

Figure 1: Radiograph of a dancer's foot in relevé position, showing an os trigonum behind the talus

Figure 2: Relevé in a normal dancer's foot

Figure 3: Dancing on pointe: maximum

Isolated tendinopathy of the flexor hallucis longus (FHL) in the region of the medial malleolus produces posteromedial ankle pain during dance, especially in plié's and jumps. FHL tendinopathy in dancers was first described by W.G. Hamilton in 1976, and he coined the term "dancers' tendinitis" to differentiate it.[1] Although in the literature a distinction is made between these two diagnoses, in dancers PAIS often coincides with FHL tendinopathy, accounting for up to 63% of their impingements.[2-6]

If conservative treatment for these conditions fails, surgical treatment yields on average 89% good or excellent long-term results in dancers.[7] The traditional surgical technique is via an open procedure, either via a lateral or a medial approach, as described by Thomasen and Hamilton.[3,8-11] The medial approach is used in isolated FHL tendinopathy or in cases with a

combination of FHL tendinopathy and (bony) PAIS. The lateral approach is used when there is a combination of FHL tendinopathy and (bony) PAIS. The lateral approach is used when the diagnosis is limited to posterior ankle impingement by a bony impediment. See figure 4.

In 2000 a hindfoot endoscopic technique was introduced by van Dijk.[12-15] Anatomical structures are visualized by removing soft tissue around the posterior aspect of the talus with a motorized shaver, staying on the safe, lateral side of the FHL tendon. Hindfoot endoscopy enables an overview of the intimate relationship between the os trigonum (or posterior [Stieda's] process of the talus) and the FHL tendon, and allows for good judgement of the posterior ankle pathology. Both PAIS and FHL tendinopathy can be treated via the endoscopic technique, resulting in very few complications.[12,16-18] See figure 5. In both procedures, open and endoscopic, a padded tourniquet over the thigh is always used.

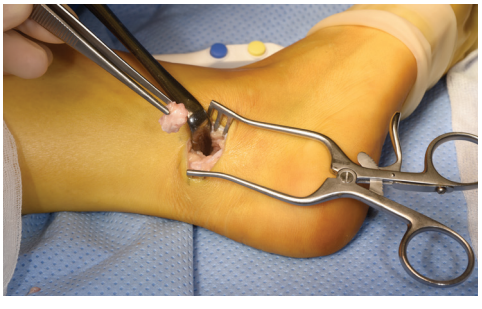

Figure 4: Os trigonum removed via the posterolateral side of the right ankle

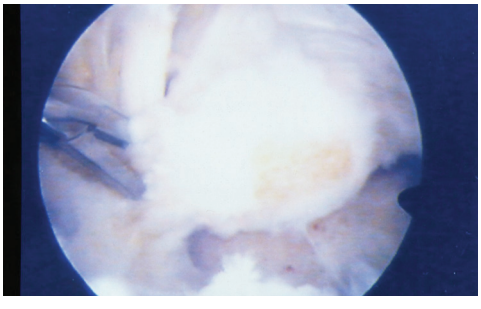

Figure 5: Hindfoot endoscopic view of the right ankle: in the centre an os trigonum is visible, the vertical structure on the left is the tendon of the flexor hallucis longus

The post-operative regimen is the same for both procedures, and involves a compression dressing or splint and weight bearing as tolerated. When range of motion is restored, dance specific rehabilitation is started.[19] In cases of painful, hypertrophic post-operative scar tissue, or an "inflammatory response," injections of bupivacaine with methylprednisolon may be considered. These practice patterns have not changed over the years. The goal is to regain a pain free and unlimited relevé and full return to dance.

In spite of two studies on this subject,[20,21] to date there is no conclusive evidence whether the "traditional" open surgical procedure or the hindfoot endoscopy is preferable for the treatment of PAIS or FHL tendinopathy in dancers.[7] Our hypothesis for this study was that the hindfoot

endoscopic technique would be superior to the open procedures in the surgical treatment of PAIS and FHL tendinopathy in dancers. We expected a shorter operation time, less morbidity, faster rehabilitation and return to dance, and better results than the open surgical procedures. This small, descriptive, hypothesis generating cohort study aims to evaluate this decision.

Material and Methods

Patient selection: In our center 97 open operative procedures for PAIS and FHL tendinopathy in 77 dancers were performed during the period 1991-2003. The corresponding author used the open procedures in the operative treatment of PAIS and FHL tendinopathy in dancers, with 90% good and excellent results.[6] However, impressed by the endoscopic overview of the hindfoot pathology and the resulting insights into the intimate relationship between the os trigonum and the FHL tendon, and after extensive training, the endoscopic approach was adopted as standard treatment in our clinic in 2002.

For this study, to avoid a learning curve effect, it was decided to study the first 19 consecutive endoscopic procedures in 16 dancers with PAIS and FHL tendinopathy performed in the period February 2002-July 2003, and to compare them with the first 20 consecutive open procedures in 16 dancers with the same diagnoses in the period May 1991-December 1996. All patients were operated by the same orthopaedic surgeon (corresponding author), and had failed conservative treatment.

Definitions: "Dancer" was defined as a professional dancer or dance teacher, dance student, or serious active amateur dancer, with the criterion of at least 2 x 1.5 = 3 hours of (structurally organized) dance classes a week. The diagnosis of PAIS or FHL tendinopathy was made on the basis of the history and physical examination, with reproduction of the typical pain in forceful plantar flexion or on palpation of the os trigonum (if present) or the FHL tendon. A plain lateral x-ray of the ankle in the relevé position (Figure 1) was made in all cases to check for the presence of a bony impediment and its possible relevance for the complaints. For the open procedures the surgical technique as described by Hamilton and Thomasen was used.[3,8-11] For the hindfoot endoscopic procedures the technique described by van Dijk was used.[12-15]

Outcome

1. We retrospectively reviewed all patient files, in which several post-operative consultations, including physical examinations, were documented. We also scored for morbidity and complications. The outcome is based on the physical examination and patient satisfaction, as documented in the files.

2. All patients were contacted via telephone for AOFAS (American Orthopaedic Foot and Ankle Society) scoring.[22-24]
3. We administered a questionnaire asking about dance-functional activities, return of dance activity to pre-injury level, limitations in daily activities and dance-specific movements, and whether the range of motion was better, the same, worse or different compared to before the operation. We also asked the patients to rate their satisfaction with the cosmetic and functional result on a visual analogue scale of 0-10, ten being very well satisfied and zero being dissatisfied.
4. All patients were invited to come to the clinic for a physical examination, including dance-functional ranges of motion (a.o. active and passive ankle dorsi- and plantar flexion), lower leg strength, cosmetic result of the scars, and ankle impingement and FHL tendinopathy tests. Measurements included four specific dance movements: demi-plié (= fully weight

Figure 6: Demi-plié

Figure 7: Fondu of right foot and ankle

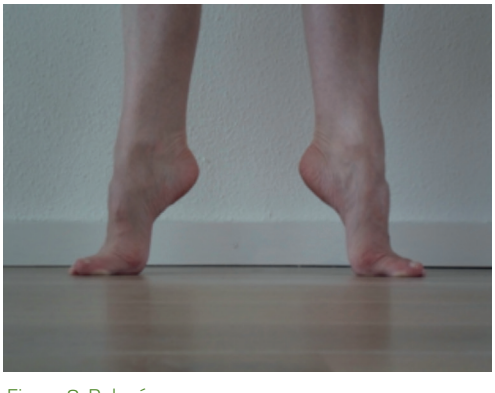

Figure 8: Relevé

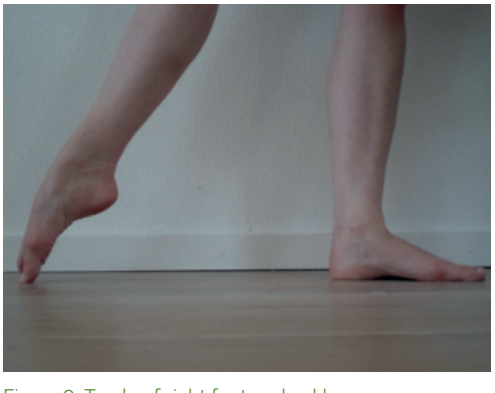

Figure 9: Tendu of right foot and ankle

bearing dorsiflexion of the foot and ankle, keeping both heels on the floor, see figure 6), fondu (= the same, but on one leg, see figure 7), relevé (= fully weight bearing, maximal plantarflexion of the ankle; see before and see figure 8), and tendu (= non-weight bearing active maximal plantarflexion of the ankle, see figure 9).

The results were graded as excellent, good, moderate, and poor, based on the four outcomes. In the end we combined the four outcomes into the final results as follows: excellent was return to full dance without any complaints; good was occasional discomfort, but no dance limitations; moderate was regular discomfort, mild dance limitations, but no limitations in other activities of daily life; poor was regular discomfort, severe dance limitations, and mild to severe limitations of activities in daily life.
The study was performed with permission of the Medical Ethical Committee of The Hague Medical Center.

Results

A total of 32 dancers (39 procedures, seven bilateral) were included in this study. We retrospectively compared the outcomes of 19 consecutive endoscopic procedures in 16 dancers (three bilateral) and 20 consecutive open procedures (four bilateral) in 16 dancers. Both groups were comparable with regard to age and dance activities (Table 1)

Table 1: Patient Characteristics

	Endoscopic N=16 patients (19 procedures)	Open N=16 patients (20 procedures)
Age, mean (range)	21.9 years (14-48)	20.2 years (14-45)
Sex	3 men, 13 women	1 men, 15 women
Dance level: ▪ Prof. ballet ▪ Prof. modern ▪ Amateur	 7 8 1	 8 6 2
Median duration of pre-op symptoms	16 months (IQR: 10.25)	15 months (IQR: 38)
Follow-up duration, mean (range)	1.9 years (1.3-2.7)	10.2 years (6.7-13.3)

In most patients' files no precipitating trauma was documented; however, in three patients of the endoscopic group a specific injury was mentioned, not directly related to the presenting complaints. One member of the open group had a specific injury.

Pre-operative pain localization as perceived by the patient was comparable for both groups (see Table 2).

Table 2: Pre-operative Pain Localization

	Endoscopic N=19	Open N=20
Posteromedial	6	6
Posterolateral	6	7
Diffuse	7	7

Pre-operative diagnoses included PAIS with (combinations of) a symptomatic os trigonum (OT), a hypertrophic posterior (Stieda's) process of the talus (PP), or FHL tendinopathy. In the open group a lateral approach was used in three operations for an isolated os trigonum. A medial approach was used in the 17 other operations (16 patients, see table 3).

Table 3: Operative Characteristics and Pathology

	Endoscopic N=19	Open N=20
R/L	11/8	11/9
Bilateral	3	4
Mean operation time	61 min	44 min
FHL	2	8
FHL + PP	10	3
FHL + OT	7	4
PP	0	0
OT	0	4
PP + OT	0	1

Most relevant data were documented in the patient files. The data were gathered at least 1.3 years post-operatively; the average duration of follow-up was 10.2 (6.7-13.3) years for the open procedure, and 1.9 (1.3-2.7) years for the endoscopic group.

Based on the physical examination and patient satisfaction as documented in the patients' files, the clinical long-term results in the open group were: nine excellent, nine good, one moderate, and one poor (90% excellent and good). In the endoscopic group, based on the same sources of data, there were nine excellent, six good, three moderate, and one poor (79% excellent and good) results. The endoscopic group had more minor complications, especially more hematomas, and more post-operative injections were needed. The hematomas may be due to extensive shaving away of soft tissue to gain a clear overview of the hindfoot pathology. However, none of these hematomas required re-intervention. Injections were given in cases of clinically observed abnormally persistent signs of posterior pain and stiffness in plantar flexion, swelling and a firm, solid mass of tissue in the Kager triangle, and reactive warmth after training or exercise, which may be due to a combination of an inflammatory response and deep scar tissue formation. In fact, this scar formation may be related to the hematomas (Table 4).

Table 4: Post-operative Morbidity / Complications / Injections

	Endoscopic n = 19 cases / 16 patients	Open n = 20 cases / 16 patients
Haematoma	5 cases	0 cases
Effusion	3 cases	0 cases
Painful plantar flexion	1 case	1 case
Infection (superficial)	1 case	0 cases
Hypersensitivity	1 case	0 cases
Injections	6 in 4 cases in 3 patients	3 in 2 cases in 1 patient

Regarding the AOFAS score: All except for three patients post-operatively reached the maximum score of 100 points on the AOFAS. One patient in the endoscopic group had mild dance-activity limitations and mild, occasional pain, and scored 87 on AOFAS. Another patient of the endoscopic group and one patient of the open group had mild, occasional pain, and scored 90 on AOFAS.

One patient of the endoscopic group (6.25%) and two patients of the open group (12.5%) did not return the questionnaire. The dancers of the endoscopic group returned to dance (exercises with support of the barre) post-operatively at a median of eight weeks (IQR: 2), and the open group at a median of eight weeks (IQR: 2). Cosmetic and subjective functional end results were comparable (Table 5).

Table 5: Satisfaction

	Endoscopic	Open
Cosmetic result	8.7 (range 7.5-10)	8.8 (range 7-10)
Functional result	8.2 (range 1-10)	8.6 (range 4-10)

According to the questionnaire, 12 of 16 patients of the endoscopic group would have the same procedure again and three would not. Of the open group, 12 of 16 patients would have the same procedure again and two would not.

Nine patients (five of the endo group and four of the open group) were able to come to the clinic for a post-operative physical examination. Their lower leg strength was found to be at pre-injury level and the scars were hardly visible; the ankle impingement and FHL tendinopathy tests were negative; ankle dorsiflexion, as measured in demi-plié, was at pre-injury level. Ankle plantar flexion, as measured actively in tendu and relevé, was pain free and improved. The findings in these nine patients were all good or excellent, and consistent with the data documented in their files.

Summarizing all four outcomes we found that in the open group nine dancers returned to dancing fully without any complaints and were graded as excellent. Another nine had occasional discomfort, but no dance limitations, and were graded as good. One had regular discomfort and mild dance limitations, but no limitations in daily life. She was graded as moderate. One had regular discomfort, severe dance limitations, mild to severe limitation of activities in daily life, and was graded as poor. In the endoscopic group grading was: nine excellent, six good, three moderate, and one poor. Thus, in the open group 18/20 cases (90%), and in the endo group 15/19 cases (79%), were excellent and good. In the open procedures, in spite of the more extensive dissection of the tibial nerve in the medial approach, no differences in the end results were found between the lateral and medial approaches (data not shown).

Discussion

We retrospectively described and compared the outcomes of surgical treatment of PAIS and FHL tendinopathy in 19 consecutive endoscopic procedures and 20 consecutive open procedures in dancers only. In our medical center the results of the open surgical treatment of these two conditions seemed slightly better than after endoscopy. A prominent finding was that the endoscopic group had more minor complications and that more post-operative cortisone injections were needed.

There may be a number of different explanations for the observed difference. First, the technique of the endoscopic procedure seems to be more demanding, and especially the "moderate" result of the first case in the endoscopic group may be due to a "learning curve" effect. However, the same applies to the open procedure: interestingly enough, the only permanent failure in our series of 190 cases in 148 dancers was in the first 20 open operations in dancers, and was therefore included in this study.[6]

Additionally, in the endoscopic group in general there seemed to be more "inflammatory response" and deep scar tissue formation, given the fact that more post-operative injections were needed (Table 4). Hematomas and stiff and painful scar tissue formation could be the cause of the slightly less favorable results in the endoscopic group. Primarily, these hematomas and build-up of scar tissue may be due to the fact that hindfoot endoscopy is not a true arthroscopy, since there is no joint space. By shaving away soft tissue around the posterior aspect of the talus a virtual joint space is created, enabling an excellent visualisation and judgement of posterior ankle pathology, but this may be the cause of hematomas and excessive, undesired scar formation. Although endoscopic procedures in general, due to smaller scars, result in more rapid recovery, this is not always the case.[25] However, the results of the endoscopic approach in PAIS and FHL tendinopathy in dancers may be improved by reducing soft tissue removal. Besides, in the open procedure the approach is more from the (either medial or lateral) side, not touching the — for dancers so delicate — direct posterior part of the hindfoot, whereas in the endoscopic procedure the approach is more concentrated on the direct posterior part of the hindfoot.

In the literature a significant correlation was found between the length of symptoms before both open and endoscopic surgery and the return to training and playing in elite soccer players with these conditions: Those who had been symptomatic for less than two years did better.[26,27] In our population of only dancers the median duration of pre-operative symptoms was almost equal (endoscopic 16 months, open 15 months), and less than two years for both groups, so this would not have influenced our end-results.

We recently performed a systematic review studying the results of surgical treatment of PAIS and FHL tendinopathy in dancers only, and found similar results after open and endoscopic operations, both in return to dance times and end results, but severe limitations were the low levels of evidence (4 and 5 only), the lack of dance-specific baseline characteristics and outcome scores, and the low number of endoscopically treated dancers in the literature: only 30 dancers (32 ankles), compared to open: 294 dancers (344 ankles). The endoscopic group thus

formed only 9% of the total number of 324 operated dancers (376 ankles).[7] This review included a small retrospective cohort study published in 2016, the first one to compare results of open surgery (22 dancers) with the endoscopic technique (13 dancers) specifically in dancers.[20] Unfortunately the two groups in this study were incomparable and the conclusion, that the endoscopic technique is superior to the open technique, lacked a firm foundation. In contrast the dancers in several older open case series[28-30] returned to dance faster than, or as fast as, after an endoscopic operation.[7]

In another systematic review in 2014, assessing the effcacy of management of PAIS in sports in general, return to sports appeared quicker for all activities in the endoscopic group, but there was no evidence supporting superior long-term results of one technique over another. However of the 487 endoscopic operations only 26 patients (5%) were dancers.[31] The results of surgical treatment of PAIS and FHL tendinopathy in sports in general may not be extrapolated to dance, given the different demands. The frequent use of the relevé position (Figure 2) in all dance styles is unique to dance, as is the pointe position (Figure 3) mainly in ballet.

There are several limitations to this study. It is a small, retrospective, descriptive cohort study with recall bias (due in part to a major difference in length of follow-ups in both groups) and a "pilot" character, not allowing for any firm conclusions or statistics. In spite of its limitations, we think that our study is an addition to the existing dance-medical literature, given that most previous studies are either more descriptive of the phenomenology of PAIS and FHL tendinopathy in dancers[32,33] and non-dancers,[33-35] or deal with the results of endoscopic treatment only in the non-dancing population, which cannot be extrapolated to dancers.[33-36] In a recent randomized controlled study, comparing endoscopic versus open excision of a symptomatic os trigonum for the treatment of PAIS in an athletic population, better results for the endoscopic technique were found, but, although 11 dancers were included in the open group and 12 in the endoscopic group, the authors failed to describe the dancers as a separate group.[37]

This is the largest series of dancers only treated endoscopically for PAIS or FHL tendinopathy in the literature through September 2016; in one cohort study 13 dancers were treated endoscopically,[20] and to the best of our knowledge a total of only 32 cases in 30 dancers have been described so far.[7]

We were not able to produce reliable return-to-performance data, due to the fact that both of our groups contained non-performing dancers, and that some dancers stopped dancing for reasons not related to their ankle injury. Recall bias resulting from the difference in follow up may have influenced the results; however, this is unlikely, since both groups reached

their primary outcome within one year, and the data were gathered at least 1.3 years post-operatively. Also, the outcomes reported in the questionnaires were consistent with those documented in the patient files.

The strength of our study is that we present a comprehensive dataset: We studied two cohorts of consecutive cases of dancers only, all patient files were available, in which pre- and post-operative data and those associated with dancing activity were documented, all procedures were performed by one orthopaedic surgeon, and all measurements were done by one independent examiner. We prevented the influence of the learning curve effect by comparing the first 20 consecutive cases of each technique. That is why there was a much longer follow-up for the dancers in the open group (10.2 years v. 1.9 years endoscopic group).

We used the AOFAS score, but, due to a "ceiling effect," this does not appear to be discriminative enough for dancers – i.e., in our study even dancers who were not able to return to their full dance schedule still scored the maximum. This raises the question as to how relevant a standard accepted scoring system, such as the AOFAS ankle-hindfoot score, is when evaluating results of treatment in high-level amateur and professional dancers.
The type of dance activity is an important factor, since classical ballet requires dancing on pointe and therefore maximum and fully weightbearing plantar flexion in the ankle. Other dance forms are more tolerant. Hence, for dancers the validation and use of a dance-specific outcome score is needed that includes both the findings of physical examination and consideration of dance functional activities, such as when to resume barre, pointe work, jumps, and performance.

In spite of the overall good long-term results of both the open and endoscopic procedures for PAIS and FHL tendinopathy in dancers, we recommend further research comparing the two techniques via a prospective, multicenter, randomized study with more dancers, to determine the place of the endoscopic approach in different subgroups of posterior ankle injuries in dancers and define the best treatment options for specific sub-diagnoses, since short-term results are relevant for dancers given the brevity of their careers.

Not withstanding its serious limitations this study is relevant to the health, well-being, training, and performance of dancers, given the paucity of clinical studies on this subject. It indicates that an endoscopic surgical treatment of PAIS and FHL tendinopathy in dancers is not axiomatically and convincingly better than the conventional open approach, and that additional studies in dancers are needed instead of unquestioned following of new trends in surgical management studied mainly in sports. We hope it helps move dance medicine from expert-opinion and

eminence-based medicine toward evidence-based medicine, aimed at assuring injured dancers of the best possible treatment.

Conclusions

1 In this small, descriptive, retrospective, single surgeon study the open approach had a slightly higher percentage of "excellent" or "good" outcomes than the endoscopic approach in the surgical treatment of PAIS and FHL tendinopathy in dancers, utilizing a non-validated classification system and not correcting for possible confounding factors. The statistical significance of these results has not been determined.
2 Post-operative morbidity in the endoscopic group was less favorable in the first year, due mainly to hematomas and deep scar formation.
3 More research in a larger sample and corrected for confounding factors is needed to define the best treatment options for different subgroups of posterior ankle injuries in dancers and determine the place of endoscopic surgery.

Post Script

Due to the results of this study we rejected our hypothesis that the hindfoot endoscopic technique would be superior to the open procedure and abandoned the endoscopic approach for the surgical treatment of PAIS and FHL tendinopathy in dancers in our clinic.

Acknowledgements

We thank Saskia Haitjema, MD, PhD, for her great help in correcting and revising the manuscript. The photographs of the dancer (the second co-author, figures 2-7) are published with her permission and made by Lucas Hagemans.

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Dance has some overlap with artistic sports:
Roosje Lampe-Cordang and Jan Adriaansen
in Cha Cha Congelado, Troyes, France, May 2016.
Photographer: André Rizzotti

PART 3 (chapters 10-12)

Limited and painful relevé in dancers due to
some miscellaneous (rare) foot and tarsal conditions.

- Freiberg's disease
- Tarsal coalitions
- Accessory navicular (os tibiale externum)

Chapter 10

Freiberg's disease as a rare cause of limited and painful relevé in dancers

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10 Freiberg's disease as a rare cause of limited and painful relevé in dancers

Abstract

Freiberg's disease, or osteonecrosis of the second metatarsal head, is an uncommon cause of forefoot pain that can severely limit a dancer's relevé. Dancers may be predisposed to the condition due to repetitive microtrauma to the ball of the foot during routine dance movements. Freiberg's disease is diagnosed by history, physical examination, and plain film radiographs. Conservative treatment in dancers is disappointing, and surgical options fail to produce uniformly good results. Previously published reports of successful surgical outcomes would, for a dancer, result in an unacceptable loss of dorsiflexion of the MTP joint. This first case report of Freiberg's disease in a dancer serves to discuss the orthopaedic and artistic implications of managing the disease in a young, active, adolescent dancer. A new surgical treatment involving modification of Mann's cheilectomy, normally used for hallux rigidus, is presented. The operation corrected the patient's pain, completely normalized the aberrant relevé, allowed her to resume dance training within three weeks, and return to full dance activity within three months.

Figure 1: Pre-operative photograph demonstrating the patient's "forced arch." The dancer is pushing the relevé of her left foot as far as possible, while standing on her right leg. Pain and marked limitation of dorsiflexion make this an unsuitable relevé for dance training.

Introduction

For the dancer, the relevé ("half toe" or "demi-pointe") is one of the most important positions of the feet, serving as the basis of most core dance footwork, including the push-off for jumps, the pivot-point for turns, and the roll-through for dancing fully "en pointe." At minimum a classical, modern, or jazz dancer must possess both 90° of plantar flexion of the talocrural joint (measured as the front of the tibia aligned with the dorsum of the foot) and 90° dorsiflexion at the first metatarsophalangeal joint (MTP-1), while the professional ballerina must have more than 100° of dorsiflexion at MTP-1 to satisfy the current aesthetic demands of the ballet world.[1-3] Pathology in the forefoot can, therefore, limit, if not terminate, a dancer's already brief professional career.[4-6] Freiberg's disease, or osteochondrosis of the metatarsal head, is a relatively uncommon cause of forefoot pain that most frequently affects the second metatarsal of active adolescent females.[7-12] Patients typically complain of forefoot pain at the extreme of joint range of motion that increases during weight-bearing.[12,13] The etiology of the disorder is multifactorial,[8,10,12-16] and there is no best algorithm for its treatment, particularly when conservative management fails. The literature is replete with surgical options; however, no single procedure produces uniformly good results.[7,9,10,15-17] Even those with reported successful outcomes result in impaired MTP joint function, particularly loss of dorsiflexion (average 15°, range 0-30°).[9,16-20] These results are unacceptable for a dancer. This is the first case report to discuss the orthopaedic and artistic implications of Freiberg's disease in an active adolescent dancer. We describe a modification of Mann's cheilectomy to the second metatarsal which corrected the patient's pain, allowed her to return to dance activity within 30 days, and restored her relevé to normal (90° of dorsiflexion at MTP-1 and MTP-2, representing a 60° gain in dorsiflexion at MTP-2).

Figure 2: Pre-operative radiograph (anterior-posterior view) demonstrating a flattened second metatarsal head, avascular necrosis, and widening of the joint space.

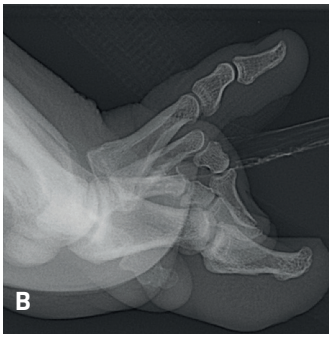

Figure 3A: Pre-operative radiograph (lateral view) demonstrating limitation of dorsiflexion by a large osteophyte on the second left metatarsal. B, Post-operative lateralview demonstrating normalized dorsiflexion of the second toe.

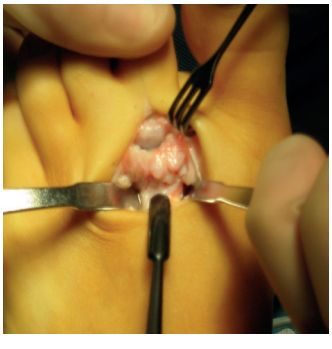

Figure 4: Intra-operative photograph revealing extent of the patient's Freiberg's disease.

Figure 5: One year post-operative "forced arch" position. The dancer has achieved full relevé on the affected side, now suitable for all forms of dance training.

Figure 6: One year post-operative radiograph, revealing resolution of the Freiberg's disease in the left second metatarsal. There was no shortening of the metatarsal head.

Case Report

In May 2006 a 16-year-old, female, pre-professional modern and jazz dancer was evaluated for chronic (three year) and progressive left forefoot pain with a concomitant decline in her ability to participate in dance training. The patient had been dancing since age 4, and followed a dance regimen of 12 hours per week. She was of healthy weight (BMI 20 kg/ m^2), was a nonsmoker, had regular menses, and took no medications. Past medical, surgical, and family histories were unremarkable, and there was no history of trauma. On physical examination erythema, swelling, crepitus, point tenderness, and a large palpable osteophyte were present at the left MTP-2. There was no hallux valgus deformity, and the length of her second toe was equal to her first. Dorsiflexion of the right MTP-1 and MTP-2 was pain-free and normal (90°), as measured with a goniometer. Dorsiflexion of the left MTP-1 and MTP-2 was decreased to 80° and 30°, respectively, producing a severely limited and painful "forced arch" (Fig. 1) and nearly impossible full weight-bearing relevé. The remainder of the physical exam was within normal limits. Radiographic examination of the foot revealed a large osteophyte with mechanical blockade of MTP joint dorsiflexion; avascular necrosis and flattening of the left second metatarsal head; widening of the overlying joint space; and loss of cartilage (Figs. 2 and 3). Loose bodies were visible on computed tomography. These findings were consistent with Freiberg's disease, Smillie class IV.[21] The patient was treated conservatively for two and a half months with custom-made orthoses for her street shoes and limitation of her dance activities to a "flat-foot barre" (no relevés, turns, or jumps on the affected side). However, there was little symptomatic improvement. In light of this and the patient's scheduled enrollment in a professional dance academy, surgical management was pursued. In August 2006, the patient agreed to undergo a modified Mann's cheilectomy applied to MTP-2. A dorsal longitudinal incision was made over MTP-2 and the extensor digitorum longus and brevis tendons were reflected, exposing a markedly deformed second metatarsal head (Fig. 4). Intraoperative dorsiflexion was 30°. Two loose bodies were removed, the second retaining a thin, fibrous attachment to the medial aspect of the head. Beginning proximal to the osteophyte, the dorsal one-third of the second metatarsal head was removed obliquely with an oscillating saw; however, disease (including a third loose body) was extensive. A second cut was made to reach healthy bone (approximately 50% of the dorsal metatarsal caput). Metatarsal length and plantar cartilage were preserved, and there was good articulation within the joint (90° dorsiflexion). The wound was closed in standard fashion. Post-operatively, the patient was immediately allowed to weight-bear with the assistance of crutches while wearing a soft shoe. She was allowed to fully bear weight after three days. At ten days post-operation, the wound was healing appropriately. The patient was seen again 23 days post-operatively in order to evaluate her request that she be allowed to participate at her new dance academy. She was pain-free upon walking. Passive dorsiflexion

of the left MTP-2 had improved to 70° (a 40° gain). She was allowed to participate in a flat-foot barre (as described above). At two months post-operation, the patient had 90° of passive MTP-2 dorsiflexion and a 65° partial weightbearing "forced arch." She began a 12-week series of dance-specific, graded rehabilitation exercises developed by the senior author for the reconditioning of dancers after foot, ankle, and knee injury or surgery.[22] At three months she had completed the rehabilitation, had a painless full weight-bearing 90° relevé on the injured side (i.e., 90° active MTP-2 dorsiflexion), and had returned to "full barre" activity. She was allowed to advance to "center-work" (i.e., dancing without support) and small jumps ("petite allegro"). At one year the patient was painfree, with continued bilateral 90° relevés (Fig. 5). She had returned to full pre-professional dance training activity for 21 hours per week (double the pre-morbid level), including "grand allegro" (large traveling jumps and leaps). Follow-up radiographs revealed complete resolution of her Freiberg's disease and no evidence of arthrosis (Fig. 6).

Discussion

Dancers represent a small but uniquely challenging group of orthopaedic patients who often have high physical, artistic, and psychological expectations during treatment.[1,23,24] They sustain one of the highest injury rates among athletes,[5] and overuse injuries of the foot and ankle are quite common[6,25,26] as a result of repetitive loading on largely unprotected feet.[4,27] Despite this, little has been published about dance orthopaedics. To the best of our knowledge, this is the first case report to address Freiberg's disease in a dancer. Freiberg's disease is uncommon and of debated etiology, though trauma is the most common cause of osteonecrosis, particularly in the foot.[10] Microtrauma and repetitive or abnormal loading to the metatarsal head may hasten the disease.[12,16] The dorsal aspects of the metatarsal head are most frequently involved, due to impingement after proximal phalanx propulsion during normal gait.[7] Adolescents are at greater risk than adults for the disorder due to immature metatarsal epiphyses.[9,11] One would, therefore, expect the incidence of Freiberg's disease to be unusually high among dancers. Dancing—particularly ballet, jazz, and modern—forces the MTP joints to an extreme range of motion, including repetitive impingement of, and maximal stress on, the dorsal caputs of the metatarsi (20kg/cm^3 "en pointe").[13] By late adolescence most pre-professional dancers have sustained a decade of training, and resultant microtrauma, on developing epiphyses. However, the incidence is not thought to be higher in this population than others.[28] This leads us to question whether our patient had an unknown, superimposed predisposition to Freiberg's disease or if the true incidence of Freiberg's disease in dancers may be under-reported. To the best of our knowledge, the patient lacked common predisposing factors for osteonecrosis (e.g., macrotrauma, systemic vascular condition, or exogenous corticosteroid ingestion). As previously

mentioned, the length of her second metatarsal was equal to her first. Recent literature has correlated longer second metatarsal length with increased forefoot pathology among dancers, although this correlation did not include Freiberg's disease.[29] Other data to support a relationship between Morton's foot type and Freiberg's disease was not found in our review of the literature. Whether specific dance activities, exposure to a certain type of dance floor, usage of a particular kind of dance shoe, or shape of her foot played a role in the development of our patient's disorder is unknown. However, should an investigation of the incidence of Freiberg's disease among dancers be undertaken, these are relevant and interesting variables to be explored. As in our case, conservative management of Freiberg's disease typically consists of supportive orthoses in the patient's street shoes and activity modification; however, at this time there is no standardized protocol. Various approaches have been proposed, including six weeks of insole support to "off load" the affected metatarsal, followed by a below-the-knee walking cast for four weeks if symptoms do not improve.[19] Others have recommended crutches and toe-touch weight bearing rather than, or in addition to, orthoses.[15] While conservative management has been proposed for non-athlete adolescents with Freiberg's disease, efficacy is 60% at best, and average time to resolution is considerable (12 to 36 months).[18] The decision to proceed from conservative management to surgical intervention is discretionary, though most operative case reports involve patients at Smillie class III or greater.[15-19] Various surgeries have been proposed, namely variations of dorsal closing wedge osteotomies of the metatarsal neck, metatarsal shortening, debridement, and metatarsal head replacement.[7-10,15-17] However, no operative procedure has yet described a suitable outcome for an active dancer. After reviewing the available options, our decision to modify Mann's "cheilectomy" to the second metatarsal was based on personal success with the procedure for treating hallux rigidus in dancers.[30] The cheilectomy, or removal of bony irregularities from the lip of a joint (cheilos is lip in Greek), eliminates diseased and impinged bone, preserves metatarsal length, and allows for increased dorsiflexion at the MTP-1 joint without repositioning or fixation of the remaining metatarsal (as in an osteotomy), thus reducing the risk of arthrosis.[31-33] Classically, one-quarter to one-third of the head of MTP-1 is removed; however, in active dancers we typically remove enough bone to allow intra-operative 90° MTP-1 joint dorsiflexion without compromising stability. By applying our dancer-modified surgical approach to hallux rigidus to this patient's second metatarsal, we were able to treat her Freiberg's disease in a manner that preserved (even improved) her ability to dance. Her return to dance activity within one month was much less than the average 5.7 months for other surgical approaches.[18] More importantly, her sustained 60° improvement in MTP-2 dorsiflexion, compared to the average loss of 15°, and doubled activity level at one year follow-up were promising results. To conclude, the orthopaedic surgeon treating the dancer may need to reconsider or even avoid standard

surgical approaches so joint range of motion is not limited by more than what is acceptable for dance training and performance. More scientific research in the field of dance orthopaedics is needed to clarify this matter. We recognize that our treatment of one patient's Freiberg's disease with the modification of Mann's cheilectomy does not validate the approach. Further epidemiologic data regarding Freiberg's disease among dancers needs to be collected before a definitive management algorithm can be created. However, cheilectomy has been successfully used for two decades as treatment in active dancers with limitation at MTP-1. Therefore, the approach may prove effective at other MTP-joints, and restore function for dancers who rely so heavily on a painfree and unlimited relevé.

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Chapter 11

Presentation, Treatment, and Outcome of Tarsal Coalitions in Dancers

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11 Presentation, Treatment, and Outcome of Tarsal Coalitions in Dancers

Abstract

Tarsal coalitions, a fusion between two or more bones of the tarsus, are a rare entity in dancers and may easily be missed. We describe the presentation, types, and treatment of tarsal coalitions in six female dancers and one male dancer (age range: 10 to 26 years) diagnosed between 2008 and 2011. The presenting complaints were ankle pain, a sense of instability, a painless foot deformity (hyperpronation), and difficulties and pain with plantar flexion and toe standing (pointe or demi-pointe). Physical examination revealed a stiff subtalar joint in all cases. Three patients with a calcaneo-navicular coalition were treated successfully by resection of the coalition with interposition of the extensor digitorum brevis or gelatin sponge. Four patients with a talo-calcaneal coalition were treated conservatively with a custom made insole for activities of daily life in combination with exercises for the ankle muscles. Three of these four dancers were able to continue their careers in dance with only minor limitations. In all, six of our dancers with a tarsal coalition were able to continue dancing. Treatment in dancers depends on the type and extent of the coalition. In calcaneo-navicular coalition, early resection of the "bar" is our treatment of choice, which is based on historic reports in the literature and our success with three patients. In our opinion the only option for talo-calcaneal coalition in dancers is conservative treatment.

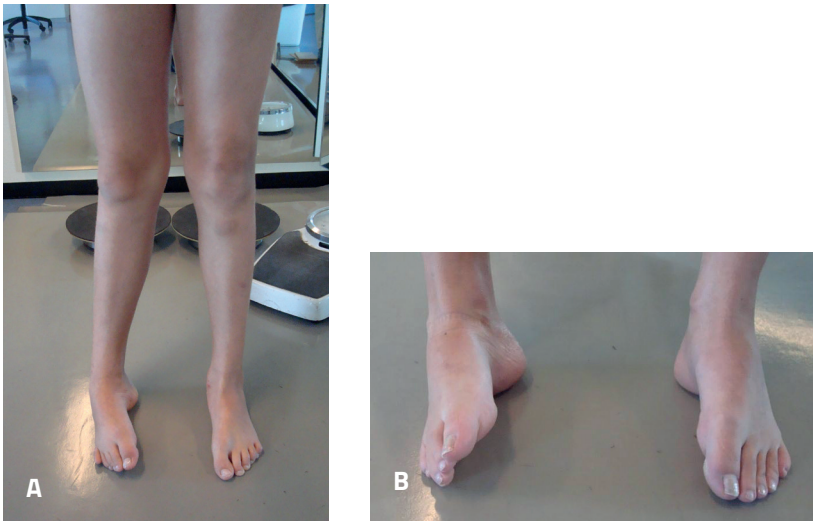

Figure 1: Examples of the modified heel tip test in two patients with a tarsal coalition. A, Patient 4: In the left extremity supination (inversion) of the foot and normal external rotation of the tibia are absent. B, Patient 5: Shows a more subtle situation; in the affected left foot supination is limited.

Introduction

A coalition, or bar, is a bony ("synostosis"), cartilaginous ("synchondrosis"), or fibrous ("syndesmosis") connection between two or more bones. A tarsal coalition can occur between any of the seven tarsal bones. Most common are the calcaneo-navicular coalition and the talo-calcaneal (subtalar) coalition.[1-4] The prevalence of tarsal coalitions in the general population is estimated to be 1% to 3%.[1,3,5] The prevalence in dancers is unknown. Tarsal coalitions are commonly congenital; noncongenital coalitions can occur as a result of trauma, fracture, operation, infection, or arthritis. The disorder is usually asymptomatic and therefore unrecognized in young children, since the symptoms rarely appear before ossification takes place in the second decade of life.[2,3] Calcaneo-navicular coalitions occur between the age of 8 to 12 years, and talo-calcaneal coalitions between 12 to 16 years of age.[2,5] The cause of complaints is unknown. Presumably the cartilaginous or fibrous coalition allows for some motion in the hindfoot joints, and ossification leads to greater rigidity in those joints, which in turn can lead to further complaints, especially of chronic pain around the ankle and recurrent ankle sprains. Restricted subtalar motion, as revealed by the (modified) heel tip test,[6,7] is suggestive of the diagnosis. In this test, the patient is observed while forcing his or her feet into supination (inversion) in a standing position (Fig. 1). A decrease in hindfoot motion is a sign of restricted subtalar motion. The hindfoot motion is the total of inversion and eversion in the foot and can be quantified by measuring the calcaneal angle (Fig. 2).[4,8] Another sign demonstrated on physical examination is a rigid pes planus, or flatfoot. This can be examined using the "Hübscher maneuver," or "Jack Test."[9,10] The test is performed with the patient weightbearing while the clinician dorsiflexes the hallux and watches for restoration of the normal arch of the foot (Fig. 3). A positive assessment results from the flatfoot being flexible

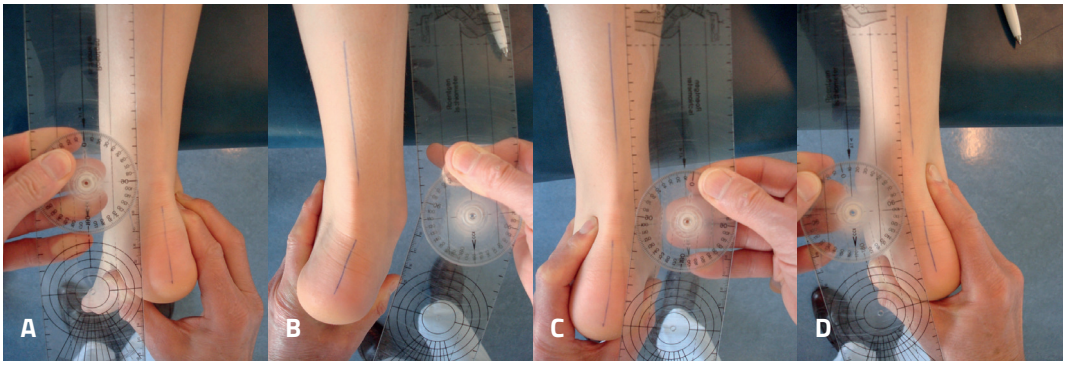

Figure 2: Patient 4. Measurement of total hindfoot motion using the calcaneal angle (dorsal view). In this example, right foot total hindfoot motion is 24° and in the coalesced left foot only 10°. A, Left foot, 0° inversion; B, Right foot, 12° inversion; C, Left foot, 10° eversion; D, Right foot, 12° eversion.

(arch formation); a negative assessment results from the flatfoot being rigid or contracted (lack of arch formation).[6,11] In the general population, conservative treatment for symptomatic tarsal coalition aims to reduce stress on the tarsus or midfoot12 by reducing activities that provoke symptoms or supporting the foot with orthoses.[5,13]

Operative treatment options depend on the type of coalition. According to the literature, a calcaneo-navicular coalition can be treated successfully by resection of the coalition.[12,14] In talo-calcaneal coalitions, resection has inconsistent results, and the most commonly used surgical treatment is a triple or subtalar arthrodesis.[5,12,13,15,16] The prevalence and optimal therapy of tarsal coalition in dancers are both unknown. The purpose of this article is to increase awareness by describing the presentation, types, and possible treatment modalities of tarsal coalitions in dancers.

Methods

Retrospectively, all consecutive patients at our institution who had been diagnosed clinically with a tarsal coalition that had been confirmed by computed tomography (CT) that had been evaluated by a musculoskeletal radiologist between 2008 and 2011 were identified. Any dancer or dance student dancing for at least 3 to 5 hours per week was included. Because of low incidence, all patient information was registered in a simple notebook and collected by the first author. Ethics approval for this retrospective case series was obtained from the Medisch Ethische Toetsingscommissie Zuidwest Holland (METC-nr: 10- 025). Data on presentation and treatment were extracted from the medical records. Patients gave informed consent to participate in the study. For the end result, the dancers were interviewed regarding their perceived satisfaction and ability to participate in their desired dance activities 6 to 36 months after the completion of treatment.

Case Series

Patient 1: A 10-year-old female recreational dancer (classical, contemporary, jazz, and tap) who danced 4 hours per week, experienced pain in the instep of her right foot and repeatedly sprained her right ankle, which limited her dancing. Physical examination elsewhere revealed a rigid subtalar joint. Lateral and antero-posterior radiographs of the feet showed no abnormalities. A CT scan of the right ankle showed fibrous tissue between the calcaneus and the navicular. An oblique (3/4) radiograph also showed the calcaneonavicular coalition in the right foot only (Fig. 4). A resection of the "bar" in the right foot with interposition of the extensor digitorum brevis was performed in a different clinic. After two weeks in a circular lower leg cast,

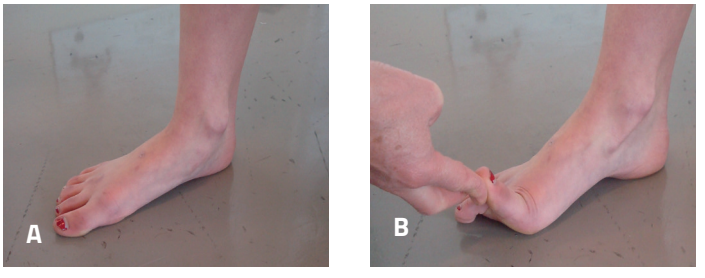

Figure 3: "Hübscher maneuver" or "Jack Test" to check for flexibility of hyperpronation. A, Normal weightbearing stance with mild hyperpronation. B, Lifting the hallux corrects hyperpronation.

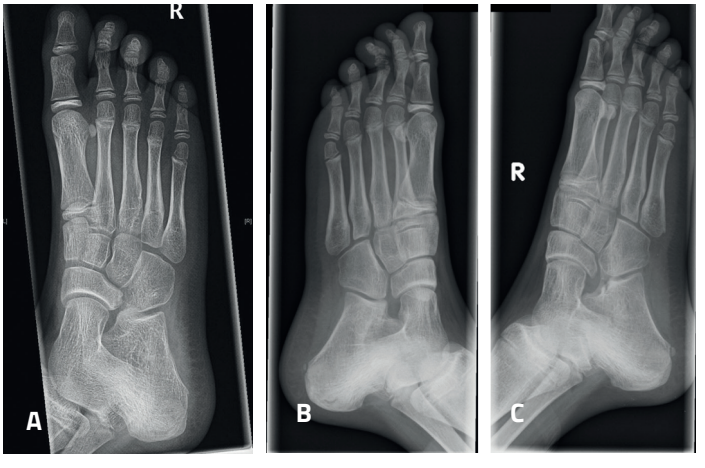

Figure 4: Patient 1. A, Oblique (3/4) radiograph preoperatively of a fibrocartilaginous calcaneo-navicular coalition in the right foot. B, Oblique (3/4) radiograph of normal left foot in the same patient. C, Oblique (3/4) radiograph postoperatively after resection of the calcaneo-navicular bar in the right foot.

she started non-weightbearing functional mobilization. Thereafter she came to our clinic and began a dance-specific rehabilitation program.[17] The schedule was graded, with progression from no-, to low-, to high-impact exercises, but was also coordinated with activities in dance class. At three and six months after surgery she had no limitations and was able to participate fully in her dance classes and increase her dance activity to 7 hours per week. A postoperative radiograph clearly showed the resection of the "bar" (Fig. 4C). At 1 year postoperatively, she was dancing without limitation for 5 to 7 hours per week. At two years postoperatively, she was still dancing 7 hours per week, had almost symmetrical subtalar mobility, but mild lateral discomfort due to minor degenerative changes in the calcaneo-cuboid joint, which have been successfully treated with orthotics.

Patient 2: A tarsal coalition had been diagnosed during a physical screening required for admission to a vocational danceeducation program in a 13-year-old male recreational dancer (dancing 5.5 hours per week) and hockey player who was anticipating a career as a break dancer. For 4 months he had been experiencing pain under the lateral malleolus of his right foot during physical exercise, more while playing hockey than when dancing. No trauma had occurred. Physical examination showed a rigid pes planovalgus on the right side and that hindfoot motion was diminished. Active dorsiflexion of the talocrural joint of both feet was equal, but passive dorsiflexion of the right foot was painful. The strength of the posterior tibial muscle of the right foot was insufficient. This was tested in maximum active plantar flexion of the talocrural joint (i.e., "pointing" or "tendu") and by having the patient invert and adduct his foot. The strength is considered to be insufficient if the patient is not able to overcome full resistance of the examiner. Plain radiographs and a CT showed a calcaneo-navicular coalition of the right foot that was beginning to ossify. A resection of the "bar" in the right foot was performed. The edges were covered with bone wax, and "spongostan" (an absorbable hemostatic gelatin sponge) was placed between the bone edges to prevent fusion. Preoperatively, exercises were given to strengthen the peroneal and tibialis posterior muscles. Postoperatively the patient was non-weightbearing for 3 weeks. Two months postoperatively, the peroneal muscles on the operated right side were still insufficient, and he was unable to participate fully in dance activities. A dance-specific rehabilitation program, including strengthening exercises for the peroneal muscles, was started. Within six months after surgery, he was able to participate fully in dance activities.

Patient 3: A presumably symptom free 16-yearold female dancer was found to have a rigid subtalar joint in both feet, more obviously on the right, during pre-vocational screening. Confronted with these findings, the patient realized that she always felt unstable on uneven

surfaces and that she avoided these circumstances to prevent ankle sprains on the right, and that she also experienced some stiffness in her right ankle. The mobility in the right talocrural joint was limited; her tendu (active plantar flexion of the foot-ankle complex, a.k.a. "pointing") was a full 90° (dorsum of foot in line with front of tibia) on the left side and 85° (which means "limited" for a dancer) on the right. There was full strength for the tibialis posterior and peroneal muscle groups bilaterally. Radiographs showed a fibrocartilaginous calcaneo-navicular coalition in both feet, more clearly on the right side (Fig. 5). This was confirmed with a CT scan. Initially, after extensive explanation, the advice was given to start a dance-education program and not "save" the feet during dance training; i.e., to dance fully. Immediately after starting the program, she experienced little pain, but found herself too limited in her dancing abilities due to stiffness of her feet, especially the right foot, in jumps and tendus. Gradually she started to experience pain and became convinced that an operation was unavoidable. Half a year after the start of her vocational dance training, the coalition or "bar" in the right foot was resected at age 17. She resumed her dance training at a professional level 6 months after the operation, and 1.5 years after the resection the patient subjectively reported an excellent result (Fig. 5C-F).

Patient 4: An 11-year-old female recreational dancer anticipating a professional career as a musical show dancer presented to our clinic. She danced approximately 10 hours per week and also trained in gymnastics for 3 hours a week. On initial presentation she was pain free and had rigid flat feet, particularly on the left side. She mentioned that she had often received

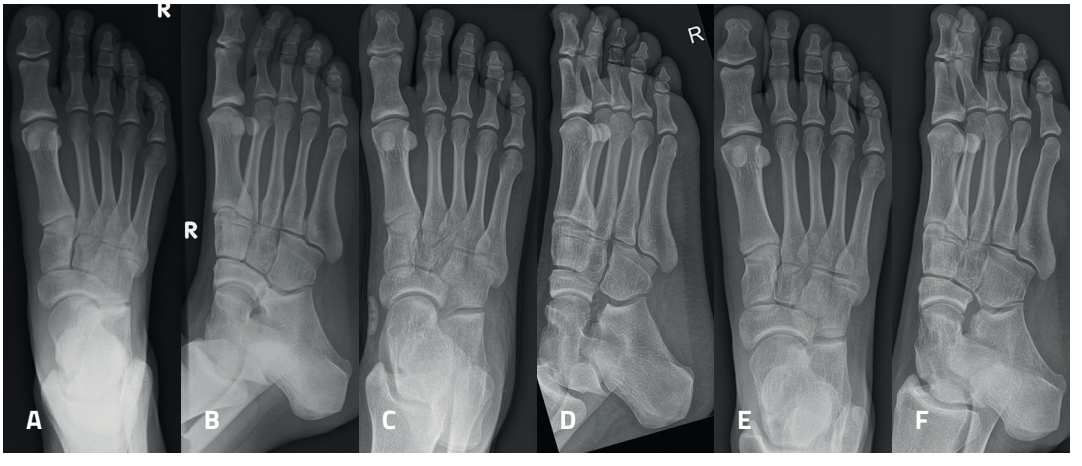

Figure 5: Patient 3. Calcaneo-navicular coalition. A, B, and C, Right foot AP view preoperatively and at 2 weeks and 18 months postoperatively (fixation button for suture of interposed m. extensor digitorum brevis clearly visible on medial side (B). D, E, and F, Right foot oblique view preoperatively and at 2 weeks and 18 months postoperatively.

comments from her dance teachers on the shape and position of her feet. Physical examination showed a rigid pes planovalgus and subtalar joint on the left side. The medial foot border did not improve in relevé (Fig. 6). Radiographs (antero-posterior and oblique) of the left tarsus showed no abnormalities, but the talo-calcaneal joint could not be properly assessed. A CT showed a fibrous talo-calcaneal coalition in the left foot in which at least 30% of the joint surface was involved. The whole middle facet of the talocalcaneal joint was involved (Fig. 7A). At the age of 13.5 years, another CT showed that the coalition had almost completely ossified (Fig. 7B). Because this patient had a pain free talo-calcaneal coalition with involvement of a large percentage of the joint surface in a weightbearing part of the joint, a regimen of ob:servation and conservative treatment was chosen. She received a custom-made night splint and an UCBL orthosis,[18] an insole constructed from a plaster mold taken while the foot is in its neutral position ("casted in situ"), in an attempt to prevent further (valgus) deformity (Fig. 8) and to support the foot in her ordinary street shoes. During follow-up, it was noticed that there was obvious wasting of the calf, weakness of the left m. tibialis posterior, and insufficient strength in the peroneal muscles bilaterally. Specific exercises were given to strengthen these muscles. After a period of 6 months, full strength and muscle balance were achieved, and she experienced no limitations in the activities of daily living or in dancing. At follow-up, she did complain of pain with relevé and tendus. Upon examination, there was tenderness of the tendon of the m. flexor hallucis longus (FHL) in the left foot. A typical FHL tendovaginitis,

Figure 6: Patient 4. Medial foot border does not improve in relevé in the left coalesced foot.

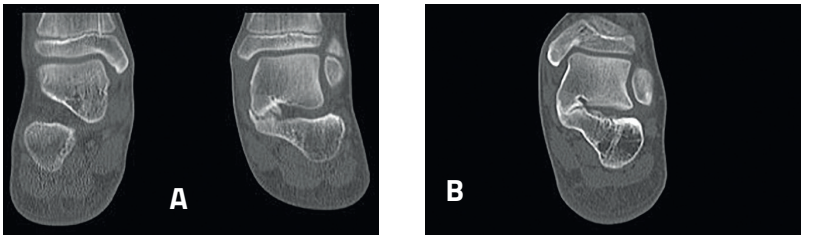

Figure 7a: Patient 4. Coronary (frontal) CT showing on the left a normal talo-calcaneal relation in the right foot and on the right a fibrous talo-calcaneal coalition in the left foot. B, Same patient two years later; talo-calcaneal coalition in the left foot has ossified.

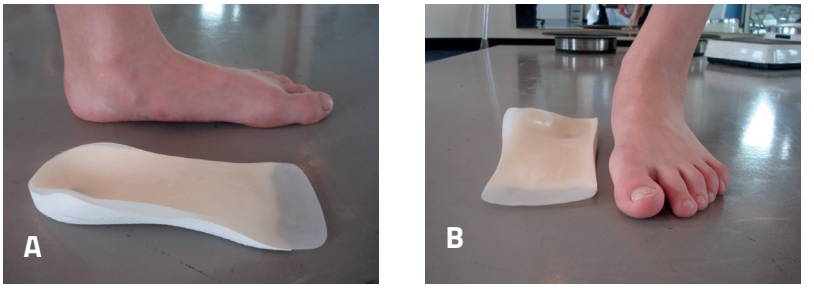

Figure 8: Patient 4. UCBL orthosis to support the foot, and prevent further (valgus) deformity. A, Lateral view of hyperpronated left foot and UCBL-orthosis. B, Frontal view of same foot and orthosis.

Figure 9: Patient 5. CT scan showing a talo-calcaneal coalition.

common in dancers, was diagnosed. It was believed that the valgus position of the foot may have triggered this "dancers' tendinitis," and at age 13.5, an operative release of the FHL tendon sheath was performed. After 6 weeks, the patient subjectively reported a good result, and with the dance-specific rehabilitation program,[17] she built up her dancing. One year after the FHL release on the left side she was able to participate fully in all dance activities, including classical ballet. She currently is training at a professional level in a vocational musical show dance academy.

Patient 5: A 26-year-old ballroom dancer presented to our clinic for a second opinion about her ankle complaints. She had experienced multiple sprains of the left ankle. After a period of intensive training, without specific trauma, she noticed increasing pain deep in the ankle, under the lateral malleolus. She had been treated with taping and had a thorough analysis where it was found that "there is something wrong" in the subtalar joint, for which she wore a cast for 4 weeks. Her lower leg then became edematous and red, so the cast was removed. After this, on first examination in our clinic, there was a rigid left subtalar joint and weakness of the peroneal muscles. Review of an earlier MRI showed an overlooked talo-calcaneal coalition with a large percentage of the joint surface involved. A CT scan revealed the coalition to be more clearly visible (Fig. 9). A removable circular walking cast was provided, and she was advised to mobilize the ankle and foot in a swimming pool. This combination of immobilization and mobilization relieved some of the pain, but the foot was still painful. To help relieve the pain, an UCBL orthosis was provided and the patient was advised to stay fit with no-impact cardio-exercises, for instance bike riding. Due to the pain in her foot, she stopped dancing completely. She was able to cope with the discomfort in daily life, having a sedentary occupation, and for this reason chose not to undergo an operative procedure.

Patient 6: A 21-year-old female professional dancer in an Asian ballet company visited our institution for a second opinion. She had instability and pain on the anterolateral side of the left ankle. There were problems with plantar flexion when dancing on pointe. As a result of the pain, her ability to perform was severely reduced, and she had to apply for Workers Compensation. She was, however, able to rehearse and had been teaching. Physical examination of the left ankle revealed limited inversion, a rigid subtalar joint, and weakness of the left peroneal muscles. There was full strength of the tibialis posterior muscles bilaterally. Radiographs of the foot, including in relevé, showed no abnormalities. At this point, no diagnosis was made. One and a half years later, a CT of the left ankle showed a large talo-calcaneal coalition (synostosis). There was complete coalescence (bony fusion) between the sustentaculum tali and the calcaneus (Fig. 10). In retrospect, the radiographs of the left foot in relevé showed a

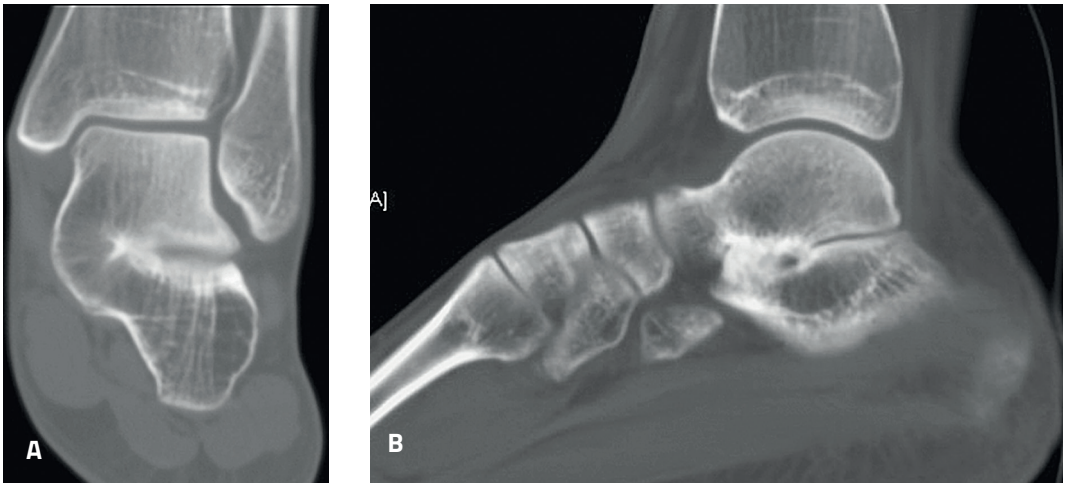

Figure 10: Patient 6. CT scans of the ankle and subtalar joint showing a synostosis between the talus and the calcaneus. A, Coronary CT view. B, Lateral CT view.

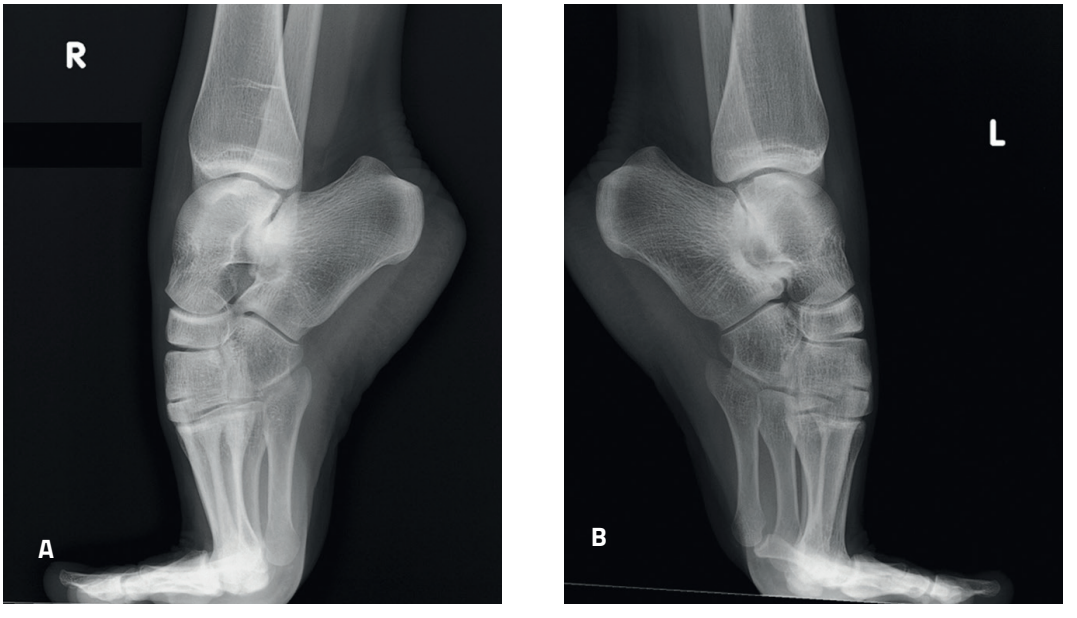

Figure 11: Patient 6. Plain radiographs "on relevé." In talo-calcaneal coalition, a "C-sign" can be seen (B), caused by fusion of the inferomedial border of the talus with the sustentaculum tali of the calcaneus.
A, Right, asymptomatic foot.
B, In the left foot a C-sign is visible in the area of the posterior talo-calcaneal joint.

so-called C-sign (Fig. 11). This is caused by fusion of the inferomedial border of the talus with the sustentaculum tali.[1,5,19] Using a dance-specific graded rehabilitation program[17] as well as specific strengthening of the peroneal and calf muscles, she was able to dance again and perform in Swan Lake on pointe. Due to the lack of compensatory movement in the subtalar joint, she will have to be careful in situations of stress, fatigue, and especially on rough, uneven surfaces or raked stages. However, due to the high demands of dancing as a soloist in a professional ballet company, and given the recurrent limitations of her left foot, she decided to terminate her performing career and now continues as a dance teacher.

Patient 7: A 16-year-old female ballet student in the last year of her vocational dance education presented with a bony lump in the tarsal tunnel behind the medial malleolus, producing slight discomfort, in spite of which she was able to dance fully for over 30 hours per week, including heavy pointe work. She had insufficient strength in the peroneals, and for a classical ballerina she had normal hypermobile talo-crural joint mobility. Sonography confirmed the lump to be bony in origin. On CT it was diagnosed to be the bony prominence of a talo-calcaneal bar, a diagnosis that had been initially missed clinically. On repeated physical examination, knowing the diagnosis, the heel tip test revealed a mildly limited subtalar motion. She was treated conservatively, including extensive explanation of the condition, strengthening exercises for the peroneal muscles, and custom made UCBL orthotics for her street shoes. Ten months after initial presentation she was able to continue her dancing career, understanding well the delicate condition of her foot.

Discussion

In general, the prime concern in the treatment of dancers is to safeguard the ability to pursue a career in dance, which is both their living and their passion. We are aware of only one previous report on tarsal coalition in a dancer.[20] With permission of the author we contacted this patient and discovered that she dances only incidentally and recreationally, by far failing to meet our inclusion criterion of at least 3 to 5 hours per week. Cohort studies have not been described. We recognize several limitations of this study: expert recall, small numbers, retrospective and nonstandardized measurement methods (we did not use a specific standardized survey tool or postoperative treatment protocol), which makes it difficult to compare our patients scientifically. However, our purpose is simply to describe qualitatively the presentation, treatment, and outcome of seven consecutive dancers with tarsal coalitions in order to increase awareness of this rare condition. Within the time frame of this study, we may have seen 1,000 to 1,500 dancers in total, so the prevalence of tarsal coalition in the dance population visiting our center is approximately 0.5% to 1%, which is slightly lower than in the general population

(1% to 3%). In spite of its rarity, it is hard to believe that in the physically demanding activity of professional dance a tarsal coalition could exist and remain overlooked for any period of time, especially in dancers dancing on pointe. A pain free foot deformity like hyperpronation, recurrent ankle sprains, or a stiff subtalar joint, especially in adolescent dance students, should raise clinical suspicion and justify referral to an orthopaedic surgeon for further analysis.
We recommend that the heel tip test should be part of any dance screening. After history taking and physical examination, the next step in diagnosis is to take plain film x-rays: AP and oblique views of the subtalar joint. In our center, x-rays on relevé are part of the protocol for all our dancer patients. This may be followed by CT or MRI, depending on availability and personal preference. We prefer CT, as this more clearly shows the bony configuration, and we believe MRI may lead to over diagnosis. Since six of the seven patients in this study did have insufficient strength of the peroneal muscles, we recommend strengthening exercises for these muscles. We consider applying UCBL orthoses, in neutral position of the feet ("casted in situ"), to be another important step in conservative treatment, aiming to prevent further (valgus) deformity of the feet. Six of these seven dancers were able to continue their careers in dance after resection or conservative treatment (including one, case 6, who did not return to her previous level of activity but continued as a dance teacher). We consider this a good result. The results of treatment in dancers seem to match the recommendations found in the literature for non-dancers. The three dancers with a calcaneonavicular bar improved after operative treatment with early resection of the bar, although one of them had mild residual complaints. However, according to the literature on non-dancers with talo-calcaneal bars, a conservative approach is preferred because in these cases resection will lead to degeneration or an unintended fusion of the resected part of the subtalar joint, which is hard to avoid since the talo-calcaneal joint is a weight-transferring joint.[2,5,12,13,15,16] Arthrodesis results in a rigid subtalar joint, which may not be compatible with the high demands of a dancer. In the only dancer who had to stop dancing (case 5) the talo-calcaneal coalition was diagnosed as late as at age 26. She might have pursued her dancing career longer and with fewer complaints if she had been aware of this condition earlier and her recurrent sprains had been prevented by adequate conservative treatment.

Conclusion and Recommendations

When a dancer is found to have decreased subtalar mobility with or without ankle pain, a rigid flatfoot (hyperpronation), or recurrent ankle sprains, clinicians should consider the possibility of a tarsal coalition in their differential diagnosis. Early diagnosis provides more treatment options and vocational choices. The decision for conservative or operative treatment in dancers depends on age, severity of complaints, and the type and extent of the tarsal coalition.

In calcaneo-navicular coalition, early resection of the "bar" is anticipated. In talo-calcaneal coalition we consider the treatment of choice to be conservative. The condition justifies a thorough analysis; it may limit, but does not necessarily mean the immediate end of a career in dance. To obtain further knowledge of the prevalence, incidence, and results of treatment of tarsal coalition in dancers, a larger multicenter cohort study is needed. In view of its rarity, international collaboration may be required.

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Chapter 12

Surgical Treatment of the Accessory Navicular (Os Tibiale Externum) in Dancers

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12 Surgical Treatment of the Accessory Navicular (Os Tibiale Externum) in Dancers

Abstract

This study is to draw attention to a relatively common anatomical anomaly and its possible operative treatment in dancers. The accessory navicular, or os tibiale externum, is an accessory bone on the medial side of the navicular of the foot at the insertion of the posterior tibial tendon (PTT). It can cause obvious hyperpronation, medial foot pain, and a limited and painful relevé in dancers. To the best of our knowledge, this is the first report on the operative treatment of the accessory navicular exclusively in dancers. Six dancers (10 feet) were treated in our clinic for a symptomatic accessory navicular Type II. Five of them (eight feet) underwent surgery, two unilaterally and three bilaterally (at the same time). All five had an excellent result at mean follow-up of 4.7 years, given that they fully resumed their professional dance activities without restriction, discomfort, or residual symptoms. One patient stopped dancing for unrelated reasons and became symptom free without further (surgical) treatment. Although no conclusions can be drawn from a retrospective case series and other treatment modalities were not considered, simple excision of a symptomatic accessory navicular Type II seems to be a good choice in dancers.

Figure 1: Relevé position in a dancer.

Case 2: Case 6. The prominence of the accessory navicular on both feet is clearly visible in relevé position.

Introduction

The foot (16%) and ankle (27%) are the most common injury sites in the dancers consulting our clinic.[1] Among these are injuries to the accessory navicular, which has many synonyms, such as the os tibiale externum, os naviculare secundarium or navicular secundum, accessory scaphoid of the foot, prehallux, and bifurcated hallux. It is the primary accessory ossicle of the foot and was first described by Bauhin in 1605.[2,3] It is located on the medial side of the navicular at the insertion of the posterior tibial tendon (PTT). This accessory ossicle is often an asymptomatic anatomic variant, being present in 4% to 21% of the population.[2,4,5] In 50% to 89%, it occurs bilaterally, most often in females.[6,7] There have been several reports on accessory naviculars, but none mentioning it in dancers were found. The prevalence of a chronic, symptomatic os tibiale externum in our dancer-patient population is unknown, but it is our observation that in dancers this can be a severe handicap, especially in adolescence. The dancers are usually referred because of a painful and limited relevé (Fig. 1) and severe hyperpronation ("rolling-in") of the feet. There are several theories about the etiology of this condition. A few of these involve posterior tibial tendinitis, pressure with irritation of the bony prominence, abnormal biomechanics of the foot, a trauma (eversion sprain) to the synchondrosis between the accessory navicular and the navicular itself, or even a (stress) fracture of the accessory navicular itself.[8-11] Ossification of the accessory navicular takes place between 9 and 11 years of age, while the ossicle becomes symptomatic mostly in the second decade of life.[5-7] The accessory navicular is easily diagnosed at first glance as a prominence on the medial side of the foot (Fig. 2). It is confirmed by physical examination and plain film radiography. The patient is usually physically active and complains of acute or chronic pain over the medial side of the foot. This pain occurs during physical activity or when wearing narrow shoes. The sign on physical examination is a painful palpable prominence of the navicular.[5-9,12-16] Resisted foot inversion will reproduce the pain. Palpation (translation) can give a sense of the mobility of the extra ossicle.[16] The imaging of first choice is plain film radiography. Usually an anteroposterior (dorsoplantar) view is sufficient, and, if needed, a 45° inversion oblique view of the foot. It has been stated that an eversion oblique view of the foot (routine standard) is the most important diagnostic tool (Fig. 3).[9,13,16] A division into three types can be made, as follows:

1 Type I is a sesamoid bone in the PTT. Some investigators give only this specific type the name "os tibiale externum."[5,6] It is usually asymptomatic.[5,6,9,12,13,16]
2 Type II is a larger triangular structure loosely attached to the navicular by fibrous tissue (synchondrosis, non-fusion, bifurcatum, or bipartite type). Type II is the most prevalent and the most likely to be symptomatic. [5,6,9,12,13,16]
3 Type III is a fusion of a large secondary ossification center resulting in a large medial portion of the tuberosity of the navicular, referred to by some as "cornuate navicular."[5,6,9,12,13,16]

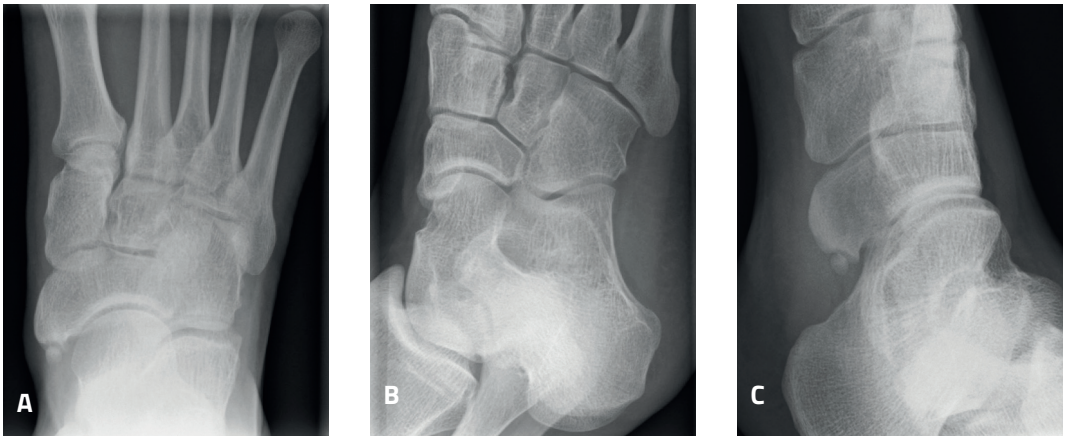

Figure 3 Case 2. A, Anterior-posterior view x-ray with the accessory navicular visible. B, Oblique (45° eversion) view x-ray; the accessory navicular is hidden behind the calcaneus. C, Oblique (45° inversion) view x-ray with a clearly visible accessory navicular.

Clinical presentation and physical examination are sufficient to differentiate between a symptomatic and an asymptomatic accessory navicular. Specific diagnosis and categorization of the problem (type of accessory navicular) does require plain film radiography. Bone scintigraphy is not reliable for diagnosing a symptomatic accessory navicular because it has a sensitivity of 100% and specificity of 50%.[12] Conservative treatment, such as a cast or a period of relative rest (reduced physical activity), can be effective, but, according to the literature, for patients who remain symptomatic surgery can provide good long-term results.[6,8,9,13,16-18] Surgery can be simple excision of the accessory bone or the Kidner procedure can be used. The Kidner procedure involves both the excision of the accessory bone and the reinsertion of the PTT.[19] Transposition of the PTT is supposed to restore its function as an elevator of the medial side of the tarsus, which is lost due to the accessory navicular. However, re-routing of the PTT is not necessary to achieve good results in treating the pain symptoms of the accessory navicular.[7,14,15] In several studies, no relationship was found between developing a pes planus and the accessory navicular. Compression due to pronation of the foot can make an accessory navicular symptomatic. [7,11,14,20,21]

After surgery for an accessory navicular, some investigators prefer a walking boot cast for 8 weeks; the Kidner procedure requires immobilization in a cast for 6 weeks.[7,14,22] In addition to excision, a few other operative techniques have been described in the literature. In young athletes, long-term pain relief was achieved by inducing bony union of the accessory navicular Type II with the os navicular by percutaneous drilling of the synchondrosis. A return to full sports

activity in 3 months has been claimed using this technique. However, it is only suitable for adolescents with open epiphyses; it can result in a non-union and has not been tested in large study groups.[23] A technique for screw-fixation osteosynthesis of the extra ossicle has also been described.[24] This is only suitable for larger ossicles, can produce problems with the hardware, can result in a non-union, and compared to simple excision, it does not give better results or additional advantages.[24,25] In all surgical techniques, except excision, the accessory navicular remains prominent and often symptomatic. To the best of our knowledge, this is the first report on successful operative treatment of an accessory navicular (os tibiale externum) in dancers.

Materials and Methods

The patient files and radiographs of a consecutive case series of six dancers (10 feet) who were treated in our clinic for a symptomatic accessory navicular were studied. The final outcomes were well documented in the files and confirmed by telephone interview, during which we asked whether the patients were able to resume their dance activities without complaints or restrictions and if they had residual symptoms.

Operative Technique

After preparing the patient in the operating room, an incision is made over the prominence of the accessory navicular in line with the course of the PTT. The PTT is split longitudinally in the middle of the tendon, preserving the insertion of the tendon, which fans out over a broad

Figure 4 Case 5. Anterior-posterior view of the left and right foot. A, Preoperatively with an accessory navicular on both sides. B, Postoperatively with the accessory navicular excised and the medial prominence of the navicular chiseled off.

area. The accessory navicular is cleared by sharp dissection and removed. If still prominent, the medial portion of the tuberosity of the navicular is removed using an osteotome, working in a proximal direction (Fig. 4). Cutting the bone in a distal direction may inadvertently lead the osteotome too deep laterally into the navicular. Any sharp edges are removed, and the cancellous bone surface is sealed with a thin layer of Ethicon bone wax after rinsing the operation area with a 0.25% bupivacaine solution containing 1:200,000 adrenalin, for postoperative analgesia and hemostasis. The split PTT is closed with absorbable sutures only. A pressure dressing is applied with the foot in neutral position. During the first 6 postoperative weeks, mobilizing exercises and partial weightbearing in firm shoes with well molded arch supports are allowed. These insoles are custom made preoperatively.[26] At 6 weeks, the dancer proceeds to full weightbearing and starts a dancespecific rehabilitation program.[27] At 3 months postoperatively, the dancer is allowed to participate fully in dance activities, including jumping and running.

Results

Of the ballet students who have been treated in our clinic for a symptomatic accessory navicular, five were female and one male between 14 and 22 years of age. Four of them had bilateral complaints, the other two were symptomatic on a single foot. They all suffered from medial foot pain, especially when performing relevé, with the duration of these complaints varying between 2 months and 5 years before the first consultation in our clinic. On physical examination, pain could be provoked by resisted action of the tibialis posterior muscle (inversion, adduction, and plantar flexion) or tapping on the (visible) prominence of the accessory navicular. All had hyperpronation of both feet; none of them had loss of strength or sensation. The radiographs showed a Type II accessory navicular in all patients in this report. Three patients, who had had their complaints for 6 months or more, were scheduled for excision of the accessory navicular at the first consultation in our clinic. Three patients received insoles as a conservative treatment, but these provided insufficient pain relief, and two of them proceeded to operative treatment. Thus, five of these dancers (eight feet) underwent surgery. All operations were performed by the first author. Follow-up ranged between 2 and 7 years. There were no postoperative complications. All five operated patients were able to dance professionally after surgery, meeting the high demands of professional dance without restriction, discomfort, or residual symptoms. We consider this to be an excellent result. In four patients the rehabilitation period to dancing fully took 3 months. In one patient, rehabilitation was prolonged to 1 year due to a painful PTT insertion, in spite of resuming full dancing at 5 months. Finally, she had an excellent result, becoming a professional modern dancer in a Dutch neoclassical dance-company. One patient was not operated: he was treated conservatively

with a cast and insoles for 6 weeks. Half a year after removal of the cast, he was still unable to dance fully without problems, and he was scheduled for operative treatment. However, due to insufficient progress in his dance technique, the vocational dance academy did not allow him to pursue his training, even if he were to be operated successfully. Hence, he decided to stop dancing entirely and became symptom free after eliminating the high demands of dance. He was not operated because his other physical activities, such as school sports, did not provoke the medial foot pains like dancing used to do. These six cases are summarized in Table 1.

Table 1 Details of the Six Dancers (10 Feet) with a Symptomatic Accessory Navicular

A	B	C	D	E	F	G	H	I	J	K	L
1	22	F	R+L	60	II	-	Yes	3	4	E	vocational student modern & ballet
2	17	F	R	6	II	-	Yes	5	6	E	vocational student modern & ballet
3	16	F	L	36	II	-	Yes	3	5	E	active recreational ballet dancer
4	15	F	R+L	24	II	Insoles	Yes	3	7	E	vocational student ballet
5	16	F	R+L	2	II	Insoles	Yes	3	2	E	vocational student ballet
6	14	M	R+L	2	II	Insoles + cast + stop dancing (other reasons)	No	N/A	1	E (after stopped dancing	vocational student ballet

A, Case number; B, Age (years) at first consultation in our clinic; C, Gender (Male/Female); D, Side foot (Right/Left); E, Duration ofcomplaints (months) before first consultation in our clinic; F, Type accessory navicular; G, Conservative treatment; H, Surgery (Yes/No); I, Time of rehabilitation to dancing fully (months); J, Follow-up (years); K, Result (excellent, good, fair, poor): E = Excellent; L, Type of dance on first consultation.

Discussion

After the first description of the accessory navicular by Bauhin, it became known as os tibiale externum. Many other names were proposed but were never adopted. With English as an upcoming language in the medical world, accessory navicular has become the most common terminology. The current investigators think it is undesirable to reserve the term "os tibiale externum" only for a Type I ossicle.[5,6] The accessory navicular (os tibiale externum) is a clinical diagnosis based on physical examination that finds a bony prominence on the navicular bone of the foot, with or without complaints. Careful history taking and examination may suffice for diagnosis; radiological evaluation confirms the diagnosis and allows for a division into three

types. Reviewing the literature and this retrospective study of the patients and their complaints provides a clear picture of a diagnostic, imaging, and treatment protocol:

1. Physical examination: On physical examination, the following aspects of the accessory navicular should be checked: pain on tapping the prominence, pain on mobilization (translation) of the prominent medial portion of the tuberosity of the navicular, resistance to pain when using the PTT (resisted adduction and inversion), and hyperpronation of the feet.

2. Imaging: The suggestion of some investigators for diagnosing the accessory navicular is an eversion oblique view of the foot.[9,13,16] In this (routine standard) view, the accessory ossicle is hidden behind the body of the navicular and is not visible (Fig. 3). Other imaging techniques, such as MRI and bone scintigram, are redundant since they neither make the diagnosis more secure nor influence the choice of treatment. A simple anteroposterior (dorsoplantar) radiograph of the feet usually reveals the accessory bone clearly, and if needed, a 45° inversion oblique view of the foot is made.

3. Treatment: The literature describes successful conservative treatment, such as a cast, but in physically active people, surgical treatment appears to be the better option. If there is a history of acute onset of the complaints or trauma (in the unusual case of an eversion sprain; landing in a "turned out" position with incorrect foot position), conservative treatment seems to fail in dancers (one case report describes successful conservative treatment in a post-traumatic case of a dancer but with a short follow-up).[28] Although a small case series, such as ours, does not allow for firm conclusions and no comparison with other therapies was made, simple surgical excision, as described, seems to be a reliable treatment in a Type II accessory navicular in dancers. It should be noted that the advice to stop dancing is not a "treatment" option in these motivated, passionate patients. The necessity for immobilization after surgery for an accessory navicular (a walking boot cast for 8 weeks14 or 6 weeks in a plaster cast after the Kidner procedure[15,19,22]) is a disadvantage for an active dancer. Rehabilitation to full dancing after prolonged immobilization takes much longer than the average 3 to 5 months experienced in our clinic. The percutaneous drilling procedure is a valued technique, which can only be used in a specific age group at a specific stage of epiphysis growth.[23] It might have provided a good comparison group to the technique described in this study; however, a prospective clinical trial was not an option given the small cohort size of professional dancers. If an osteosynthesis is used, the screws and other hardware can produce discomfort and may require a second operation for removal. The surgical technique used in removing the accessory navicular in this group of dancers is simple excision, shelling out the accessory bone, and leaving the insertion

of the PTT intact, albeit sometimes "weakened." If in doubt, a plaster of Paris boot may be given immediately postoperatively for 6 weeks. The dancer patient is warned before the operation that this may be necessary, but in none of our cases was it required. In our opinion, it is unnecessary to divide the PTT entirely (transversely) and repair it anatomically, as suggested by some investigators.[22]

Conclusion

A patient's history can provide a clue to the presence of a symptomatic accessory navicular (os tibiale externum), which can be diagnosed by physical examination. The presence and type of the accessory bone is confirmed on plain anteroposterior radiography of the foot and, if needed, a 45° inversion oblique view of the tarsus. Although this is a retrospective case series of six dancers (10 feet) and no comparison with other treatment modalities is made, in our clinic the simple excision of a symptomatic accessory navicular Type II has proven to be a reliable treatment for professional dancers. Even in acute trauma or in the case of short-term symptoms, conservative treatment seems to fail in dancers. Although active young people, such as one of our patients, may become symptom free by eliminating the high demands of dance, this, of course, is no "treatment" option in committed dancers. All five dancers (eight feet) operated in our clinic had an excellent result, given the fact that they were able to resume fully their professional dance careers, without restrictions, discomfort, or residual symptoms.

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PART 4: Chapter 13

General discussion, conclusions, future perspective and recommendations.

13 General discussion, conclusions, future perspective and recommendations.

1. Introduction
2. Guidelines for clinical studies in dance and musicians' medicine and proposal for standardized levels of 'Return to dance' (RtD)
3. Research questions arising directly from the publications in this thesis
4. Additional research on painful and limited relevé in dancers: hallux rigidus and injuries of the sesamoids
5. Recent and present research in Performing Arts Medicine in The Netherlands
6. Suggestions for future clinical research in dancers and musicians
7. General recommendations for the future of Performing Arts Medicine in The Netherlands

1 Introduction

Dance Medicine is moving slowly from Eminence Based Medicine (level of evidence five: expert opinions) towards Evidence Based Medicine. Although, of course, prospective interventional clinical studies and meta-analyses of randomised clinical trials are the ultimate goal, Performing Arts Medicine has barely left the pioneer phase and is slowly progressing through the different levels of Evidence Based Medicine. That is why most of the studies in this thesis are level four and five.

In chapter one of this thesis a legitimation of Performing Arts Medicine is given, and, as we have seen in this thesis, dancers and musicians form a interesting subgroup of orthopaedic patients. Due to the high and subtle demands of dancing and playing a musical instrument, dancers and musicians are relatively vulnerable, and, if injured, managing their demands and expectations of the healing process can be challenging.
That is why in the treatment of most orthopaedic injuries in dancers and musicians, especially

Table 1: Four steps "stepped care" - approach in dancers and musicians

1.	diagnostics and extensive explanation of the possible causes of the injury, and how to prevent and / or alleviate them;
2.	non-invasive conservative treatment:
	a. immobilisation / stabilisation (brace, plaster, splint, orthotics, inlays),
	b. allied health care: e.g. body-, ergo-, hand-, manual- or physio-therapy,
	c. (neuro-) psychology, psychiatry,
	d. medication: e.g., paracetamol, NSAID's, beta-blockers, antidepressants;
3.	invasive conservative treatment: e.g. diagnostic and / or therapeutic injections;
4.	surgical treatment.

in the chronic, overuse-type injuries, in the Medical Centre for Dancers and Musicians (MCDM) a structured, four steps stepped care - approach is used. See table 1.

In over 95% of the injuries of dancers and musicians the choice of treatment is conservative, but if an operation is anticipated, 'it is worth going the extra mile..': every effort must be made to achieve an optimal outcome.[1]
In rehabilitation of dancers a graded dance specific rehabilitation protocol is used. [2]
The same strategies apply to support a musician's recovery and return to play after injury or operation. [3]

Both in dancers and musicians prevention and preventive rehabilitation are primary, using simple strategies as warming-up before practising, frequent short breaks, mental practice (visualisation), proper activity sequence and avoidance of accumulative overuse.
Dancers and musicians may be considered difficult and time-consuming patients, partly because they often present with seemingly minimal injuries, but which have great impact. However the opposite is true: with no exception all dancers and musicians want to return to their passion and are extremely motivated to cooperate in the healing process: the ideal patient!

The goals of this thesis are to enhance awareness for Performing Arts Medicine in general and in particular to the relevé position in dance. In chapter one attention is drawn to the fact that the results of treatment of presumably the same orthopaedic injuries in sports cannot be extrapolated to dance and have to be studied in dancers exclusively.

Hopefully this thesis adds some pieces of clinical knowledge and experience to the exciting field of performing arts medicine. To summarize a few:

- Hyperpronation is common in dancers and treatment of hyperpronation-related complaints with custom made arch supports yields good results and shows a high degree of compliance in their use in dancers.
- If conservative treatment fails, dancers with posterior ankle impingement syndrome (PAIS) and / or flexor hallucis longus (FHL) tendinopathy, may confidently engage in surgical management, given the good outcome and low risk.
- Freiberg's disease is rare, but has serious orthopaedic and artistic implications for a dancer. A new surgical treatment for this disease in dancers is presented.
- Tarsal coalitions are a rare entity in dancers and the diagnosis may easily be missed. For early diagnosis of tarsal coalitions it is recommended to perform the "heel-tip - test" in every dance screening. [4] Dancers with a coalition may be able to continue dancing,

treatment depending on the type and extent of the coalition.

- The presence of an accessory navicular may lead to over-estimation of hyperpronation. In dancers a symptomatic accessory navicular type II may successfully be treated by simple excision.

2 Guidelines for clinical studies in dance and musicians' medicine

As the research presented in the systematic review (chapter seven of this thesis) makes abundantly clear, there is a paucity of clinical studies of PAIS and FHL tendinopathy in dancers, especially with regard to the epidemiology, natural history, and outcomes of conservative treatment. Moreover the available studies were of levels of evidence four and five only. Comparison between studies was almost impossible due to insufficient description of dance-related baseline characteristics and the inconsistent use of different outcome scores, thus creating large heterogeneity for both inclusion, as well as outcome criteria. It is a challenge to raise these clinical studies in dance-medicine to the next methodologically sound level. As we found that the postoperative morbidity on the short term is hardly studied, studies on surgical treatment should include validated outcome measures of short-term follow-up. This is especially relevant for dancers, given the brevity of their career.

Based on these findings we suggest the following three specific guidelines for clinical studies in dance medicine:

1 Describe and specify the type of dance and the level of participation:
Generally these factors are poorly described and rarely specified, whereas they have an enormous impact on the levels of demands, required of the dancer. Outcome of any type of treatment in dancers can only be evaluated consistently, if these factors are clearly described and specified, including in the early postoperative phase.

2 Use consistent and preferably dance-specific quantitative outcome reporting: this is mandatory to make comparisons, firm conclusions and recommendations possible. Since 2002 quantitative pre- and postoperative (outcome-)scoring has become more common. During our research, by applying the AOFAS score, we found it to be not discriminative enough in dancers, because it has a ceiling effect: given the high and specific demands of dance the AOFAS score may be 90/100 or more in spite of the fact that the dancer is unable to dance fully without limitations. [5-7] This is a relevant finding of our study and raises the question how relevant a standard accepted scoring system is, when evaluating results of treatment in high level amateur and professional dancers. A dance-specific outcome score would be the preferred outcome measure. The Dance Functional Outcome System (DFOS) [8] is a dance specific PROM, a self-reported questionnaire, that

focuses on dance-specific, functional movements, like relevé, which are unaddressed in other sports- or generic questionnaires and which provides a tool for investigating the clinical efficacy in dance medicine. [9] We recommend this tool to be validated and used pre- and postoperatively at standardized intervals in combination with graded dance specific rehabilitation. [2] Unfortunately the DFOS lacks a doctors' section with dance-specific findings at physical examination, including measurements of specific dance-movements, like demi-plié (= fully weight bearing, maximal dorsiflexion, heels remaining on the floor), fondu (= single leg, fully weight bearing, maximal dorsiflexion, heel remaining on the floor), tendu (= non-weight bearing active maximal plantarflexion of the ankle) and relevé (= fully weight bearing, maximal plantarflexion of the ankle): see figures 1 - 4.

Figure 1: Demi-plié

Figure 2: Fondu of right foot and ankle

Figure 3: Tendu of right foot and ankle

Figure 4: Relevé

In a pilot study (unpublished data) we found that the DFOS is useful only for theatrical dancers with a background in ballet, given its terminology. Hence a more general dance specific functional outcome is preferable (see Proposal in table 2).

3 Use standardized levels of 'Return to dance' (RtD) as a qualitative functional outcome measure: RtD is a good qualitative, functional outcome measure, provided it is clearly defined, i.e. the type of dance, level of participation and levels of return to dance are described and differentiated. In the studies found in the systematic review (chapter seven of this thesis) Return to dance or Return to previous level of participation was generally used as primary outcome measure, but the descriptions varied and were rarely specified.

Some examples (quotes) found in the different publications:

- permitted to return to dancing en pointe
- back to normal dancing
- performing on stage
- resumed her professional ballet activities
- danced at her former level
- complete return to dancing
- was allowed to return to dance, including dance on pointe
- able to resume the en pointe position and high jumping

This variety makes comparison and firm conclusions impossible, since within one type of dance RtD can have many different meanings, e.g. starting exercises with support (at the barre), resuming daily training in the group or company (class), or return to full dance, and, if applicable, Return to performance (RtP). The latter is not a good outcome measure, since performances have greatly varying demands, the easiest being a more acting part, and the most demanding includes heavy dancing (travelling jumps, turns and acrobatics), and, if applicable, dancing on pointe. Besides, RtP is not useful in amateur dancers.
It is recommended to use RtD as an outcome measure, differentiating, defining, and standardizing the levels of RtD, in a way universally applicable to all dance forms (not only ballet), and according to the principles of graded and preventative rehabilitation, [2] as proposed in table 2.

Table 2: Proposal for standardised levels of Return to dance (RtD)	
The dancer is able to engage in the following dance activities (seven steps):	
1	Non weight bearing: (emphasis is on regaining mobility)
2	Partially weight bearing: (emphasis is on regaining mobility and strength)
3	Fully weight bearing: (emphasis is on regaining strength and endurance)
4	No impact: fully, assisted weight bearing, including relevé and demi-plié, without turns or jumps (in ballet: barre); (emphasis is on regaining strength and endurance);
5	Low impact: fully, unassisted weight bearing, including explosive relevé and small jumps and turns (in ballet: class - petit allegro); (emphasis is on regaining timing and coordination);
6	High impact: big jumps, running and acrobatics (in ballet: class - grand allegro or full class); (emphasis is on regaining self-confidence);
7	Full dance performance, including description of the type of dance and level of participation (in ballet: performance on pointe); (emphasis is on tertiary prevention: prevent it from happening again);
These seven steps can be translated into every dance style. The levels of the rehabilitation process are included in brackets.	

Summarizing, to overcome the described insufficiencies in clinical Performing Arts Medical research in general, (comparative) cohort studies are recommended with:

- a good description of the demography, type of dance resp. music, and level of participation,
- pre- and post-intervention pain scales to quantify results
- the systematic use and report of validated functional, dance resp. music specific outcome scores,
- a, preferably standardized, definition and differentiation of the levels of 'return to dance', resp. 'return to music' both pre- and post-treatment.

Whenever possible, a prospective randomized controlled design should be used comparing different conservative and operative treatment options in injured dancers and musicians.

3 Research questions arising directly from the publications in this thesis

The research presented in the different chapters of this thesis makes clear how much clinical research still has to be done in orthopaedic dance-medicine, and probably in performing arts medicine in general. Several research questions arise directly from the publications in this thesis:

1 Although the graded dance specific rehabilitation protocol for dancers, presented in chapter four of this thesis, has proven its applicability and efficacy in the daily dance-medical practice of the MCDM, it has not been validated. A biomechanical analysis of the different steps of this protocol and a clinical user satisfaction study seem logical next steps. [2]

2 In chapter five it was shown that the clinical grading of hyperpronation, based on the Hübscher maneuver, in a small sample of dancers presenting to the clinic with hyperpronation-related symptoms, correlates with the calcaneal angle. However, more research is needed to find the best physical examination tool that not only correlates with clinical severity of hyperpronation, but also can be adopted as a standard, time-efficient method of measuring and grading hyperpronation in dancers.

3 The dancers in the study presented in chapter six of this thesis demonstrated a high rate of compliance in obtaining and wearing their orthotics and experienced a significant decrease in pain. Further research is needed to investigate the decrease in pain and decrease in the medial longitudinal arch angle (i.e. decrease in hyperpronation) due to orthotics in a larger study group of dancers.

4 As shown in part two of this thesis, studies on conservative treatment of PAIS and FHL tendinopathy hardly exist and are of low quality. Furthermore isolated PAIS, PAIS combined with FHL tendinopathy and isolated FHL injuries in dancers seem different pathological entities. Hence more research is needed to find out:
   a. in which cases conservative measures are most beneficial, and, if so, which conservative treatment modalities are most effective.
   b. in which cases early operative management should be considered or avoided, taking into account demography, dance type and level of participation.
   c. what is the place of endoscopic surgery in posterior ankle problems in dancers
   d. which pathology implicates worse outcomes or delay in return to dance.

5 The miscellaneous forefoot and tarsal conditions causing a limited and painful relevé in dancers, as discussed in part three of this thesis pose an additional challenge, since they are so rare, even in the non-dancing population. Epidemiologic data regarding Freiberg's disease among dancers need to be collected before a definitive management algorithm for dancers can be created. And to obtain further knowledge of the prevalence, incidence, and results of treatment of tarsal coalition in dancers, as well as of accessory navicular in dancers, larger multicenter cohort studies are needed. In view of the rarity of these three entities, international collaboration is required.

4 Additional research on painful and limited relevé in dancers: hallux rigidus and injuries of the sesamoids

Relevé requires maximal plantarflexion (90°) in the ankle or talo-crural joint, and maximal (> 90°) dorsiflexion in the forefoot (especially in the first metatarso-phalangeal (MTP-1) joint) in a controlled, persistent, extreme, active and fully weight bearing manner (see fig.5 and 6).

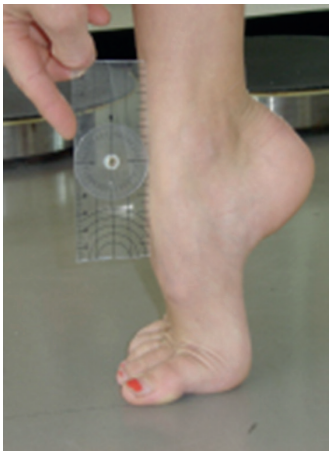

Figure 5 Relevé: maximal plantar-flexion in the ankle joint

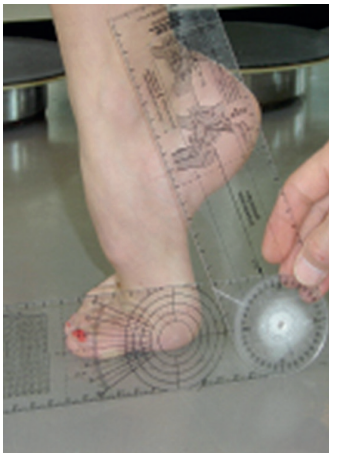

Figure 6 Relevé: maximal dorsi-flexion in the forefoot

It is obvious that painful and limited relevé in dancers can be due to both ankle injuries (limiting plantarflexion) and forefoot injuries (limiting dorsiflexion).

Posterior ankle problems are addressed in part two of this thesis, and the evaluation of treatment of PAIS and FHL tendinopathy in dancers forms an important part of this thesis. However, two major groups of forefoot problems as a cause of impaired relevé in dancers are left unaddressed in this thesis:

- hallux rigidus and
- sesamoid injuries.

Both of these entities are challenging enough to be evaluated in more detail in order to have a more evidence based approach in a clinical setting, thus providing an optimal treatment for these dancer-patients. For that matter two potential theses might evolve form this:

Hallux rigidus (degenerative, juvenile, and iatrogenic hallux rigidus) as a cause of limited and painful relevé in dancers. It is a clinical observation that hallux rigidus is common in dancers, and that limited relevé due to hallux rigidus means the end of a dancers' career, in all dance-styles and both for professionals and amateurs. Iatrogenic hallux rigidus after hallux valgus surgery in particular must be avoided. Mann cheilectomy has been successfully used for over two decades as the treatment of choice in active dancers with limitation at the MTP-1 joint in the MCDM.[10]

As for hallux rigidus in dancers some areas to be evaluated can still be identified:

1 Systematic review: prevalence and results of treatment of hallux rigidus in dancers
2 Validation of clinical weight-bearing dorsiflexion testing of MTP-1 joint (intra- and inter observer reliability and correlation with plain x-rays in relevé position);
3 Results of Mann cheilectomy as surgical treatment for "degenerative" hallux rigidus due to dorsal abutment in dancers;
4 The use of a toe CPM (continuous passive movement) machine after Mann cheilectomy for "degenerative" hallux rigidus, in dancers;
5 Dorsal closing wedge (modified Akin) osteotomy for juvenile hallux rigidus (without osteoarthritis or dorsal abutment) in dancers.
6 Hallux rigidus after hallux valgus surgery in the general population: fact or myth? Consequences for dancers. A multicenter study.

Sesamoid injuries as a cause of limited and painful relevé in dancers. It is a clinical observation that injuries of the sesamoid bones of the MTP-1 joint are fairly common, often overlooked, and hard to treat, especially in dancers. Thus, as for sesamoid injuries, some areas to be evaluated could be:

1 Systematic review: Prevalence, diagnosis, natural history and results of treatment of sesamoid injuries in general and particularly in dancers
2 Reliability and correlation of axial sesamoid views on plain x-rays compared with MRI
3 Results of conservative treatment of sesamoid injuries in dancers using inlays
4 Differentiating between fractures and avascular necrosis (AVN) of the sesamoids; proposal for staging of AVN of the sesamoids
5 Results of excision of the lateral sesamoid in dancers: plantar or dorsal approach?
6 Results of excision of the medial sesamoid in dancers

5 Recent and present research in Performing Arts Medicine in The Netherlands

When the author founded the MCDM in 1993 it was a novelty. The epidemiological data of injuries in dancers and musicians were scarce and only derived from "self-reported" questionnaires, lacking a medical diagnosis. Dancers and musicians openly admitting that injuries were present was a taboo. There were not even sociological data of the numbers of professional and amateur dancers or musicians in The Netherlands available. There was hardly any medical scientific literature. The journal Medical Problems of Performing Artists (MPPA), although established in 1986, was still in its infancy. The Journal of Dance Medicine and Science (JDM!S) had its first volume in 1997.

Fortunately, the landscape of Performing Arts Medicine internationally and in The Netherlands is changing. Celebrating the 25th anniversary of the MCDM, the NVDMG will co-organize an International Conference on Performing Arts Medicine: "ICPAM 2018" with as motto: "State of the Art in Performing Arts Medicine" (see: www.nvdmg.org and www.icpam2018.org).

Thanks to the research of L.M.(Laura) Kok, MD, there is a growing body of knowledge in The Netherlands of epidemiology both in amateur and professional musicians.[11-17] Several others, like V.A.E.(Vera) Baadjou, MD in Maastricht, [18-21] G.J.F (Gert-Jan) de Haas, MSc, BMus, neuro-psychologist in The Hague, [22-24] A.E.(Anandi) van Loon-Felter, MD, in Amsterdam, [i] and K.H.(Kees Hein) Woldendorp, MD in Beetsterzwaag, [25-30] are doing clinical research in Performing Arts Medicine, hopefully resulting in PhD dissertations in the near future.

Although she lives and works now in the USA, the scientific work of M.E.(Mamie) Air MD, is worth mentioning here, as it has part of its origins in the Netherlands, since she worked as a Fulbright Scholar in the MCDM in 2007-2008, when she was a medical student at Yale University School of Medicine. Her scholarship in the MCDM resulted in several Performing Arts Medicine publications. [2;31-39]

This enumeration is not intended to be complete.

6 Suggestions for future clinical research in dancers and musicians

As stated in the introduction of this chapter, Performing Arts Medicine has barely left the pioneer phase and is gradually progressing through the different levels of Evidence Based Medicine. PASSION-MD, as described in chapter two, is a 25 years cohort study containing the clinical data of the thousands of dancer- and musician-patients consulting the MCDM, since its inauguration in 1993. Research within this database has IRB approval and may stimulate

[i] Mrs.A.E.van Loon-Felter has no publications yet. She does research on Healthcare for Dancers at the Coronel Institute (Netherlands Centre for Occupational Diseases), Academic Medical Centre, Amsterdam, and and on the sesamoid bones of the foot in the MCDM in Haaglanden Medical Centre in The Hague.

clinical research in Performing Arts Medicine. It may initiate observational, clinical, cohort-studies with even better succinct definitions of diagnoses as well as well-defined conservative and surgical treatment options of injuries in dancers and musicians.
Based on his over 25 years of clinical observation and on his findings in the different chapters of this thesis, the author offers some suggestions for future research in dancers and musicians. Of course this list is incomplete.

Dancers

1. Due to the combination of facts that a large proportion of dancers is hypermobile and that most dancers push themselves to the limit of joint excursions, soft tissue impingement is a common feature. Some examples are kissing spines in the lower back, femoro-acetabular impingement (FAI) in the hip, Hoffa impingement in the knee, anterior and posterior impingement in the ankle, sinus tarsi syndrome and turf toe in the foot. Description and validation of soft tissue impingement tests for these diagnoses in hypermobile dancers seem valuable for daily dance medical practice.
2. As introduced in paragraph two of this chapter validation of a Dance Functional Outcome System (like the DFOS) for ballet, jazz and modern dance, but especially for dance forms other than theatrical dance, such as ballroom, latin, urban, hiphop, tapdance, etc.) is mandatory. On top of that, a Dutch translation of the DFOS for The Netherlands will have to be provided and validated.
3. In dance, especially in ballet, active external rotation of the hips is a prerequisite. Hence it comes as no surprise that complaints related to the external rotator muscles of the hips, like the piriformis syndrome, are common in dancers. Succinct definition, objective criteria, prevalence, conservative treatment options, results of (CT-guided) botulinum toxin injections and possibly endoscopic release, need to be described in dancers.
4. For unknown reasons spondylolysis is more common in balletdancers, [40] gymnasts, [41] eskimo's, [42] Welsh coalminers [43] and dachshunds [ii] . In dancers and gymnasts this is possibly related to rotatory and hyperlordotic overuse of the lower spine. The impact, prevention and management strategies of spondylolysis in adolescent dancers deserve profound attention.
5 Causes of dance-injuries are multifactorial and bad dancefloors seem to be a major risk factor, since dancers do not wear protective shoes. The surface qualities (slip and grip) of

[ii] 1982: personal communication W.G.Hamilton MD, orthopaedic surgeon New York City Ballet Company.

the dancefloor may be a causative factor in acute injuries (e.g. sprains, fractures), whereas chronic injuries (e.g. tendinopathy, impingement syndromes, stress fractures) may be more related to the dynamic qualities (spring-effect and shock absorption) of the dancefloor and its substructure: too hard floors (vinyl on concrete) are notoriously dangerous, sprung dancefloors presumably are safer. The impact of dancefloors on dancers and its relation to dance-injuries, both as a preventive measure and as a causative factor, is an important research area, not yet sufficiently covered in clinical dance-medicine.

Musicians

1 Neuropathy of the ulnar nerve (ulnaropathy) in the 'cubital tunnel' at the elbow is surprisingly frequent in musicians, constituting up to 9 % of all musicians' injuries. [44] The factors contributing to the entrapment of the ulnar nerve in musicians are extensively described in chapter three of this thesis. In neurosurgical daily practice, nowadays it is well accepted routine to restrict surgical treatment to neurolysis and refrain from (submuscular or subcutaneous) anterior transposition. [45-51] However conservative and surgical treatment of ulnaropathy in musicians may require a different approach. In the MCDM regularly anterior transposition of the ulnar nerve, using a non-compressing fasciodermal sling, is chosen, especially in musical instruments requiring prolonged flexion in the elbow, like the left arm in cello playing. The choice for this specific surgical technique is because the author trained in New York with the inventor of this procedure. [52] This leads to the research question: which are the diagnostic criteria in musicians, and are conservative and operative treatment-protocols in the general population applicable in musicians, especially in musical instruments requiring prolonged flexion in the elbow(-s)?

2 Osteoarthritis of the first carpometacarpal joint (CMC1) at the base of the thumb (also known as rhizarthrosis) is a common osteoarthritis in the human body, both in the general population and in musicians. [44] In the MCDM the first choice of treatment is a simple thumb splint in activities of daily life. Depending on the instrument and the injured side, the splint may be used during music making. If operation is unavoidable musicians in general need more mobility than strength. Hence a simple resection of the trapezium may give satisfying results in spite of slightly diminished grip strength. Given the frequency of this diagnosis and the implications for both professional and amateur musicians, results of treatment, both conservative and surgical, of rhizarthrosis in musicians need to be studied in depth.

3 Hypermobility in musicians' hands is a good servant, but a bad master. For lack of active control of these hypermobile finger joints in musicians the temporary use of silver-ring splints has proven to be useful in the daily practice of the MCDM. A perfect example

is the hypermobile locking swan-neck deformity. [44] Silver-ring splints are also used to great satisfaction in polyosteoarthritis in the fingers of musicians, especially in deviating osteoarthritis of the distal interphalangeal (DIP) joints. Although the advantages of these simple splints hardly need further clarification, the level of evidence of this conservative treatment in musicians at present is expert opinion only, a cost-effect study is feasible and the risks of such a study are low. [53]

4 Focal Hand Dystonia in Musicians (FHDM), also known as 'musicians' cramp', is a relatively rare, task-specific, pain-free disorder of control, causing unintentional, abnormal movements and/or positions in a part of the body directly involved in playing a musical instrument. See figure 7.

Fig.7: Focal Hand Dystonia in Musicians: uncontrolled flexion of right index finger.

It is a for the musician extremely serious disorder of control and coordination, leading to a total inability to perform at the desired, original musical level. The exact cause of the disorder remains unknown and there is no generally effective therapy. [44;54] It is related to writers' cramp and as such dates back to the Middle Ages. It may be considered the "holy grail" in Performing Arts Medicine. Recent publications focus on the role of the central nervous system and on motor pattern relearning. [54] However the author supports the etiology hypothesis, that, at least in some cases, primary (i.e. of as yet unknown cause) FHDM is caused by a loss of central motor control, initiated by a failure of coping mechanisms, which (try to) compensate for the effects of peripheral local movement disturbing factors in the hand. [54-56] Support for this hypothesis is found in the fact that in some patients, in whom - based on this hypothesis - anatomical constraints in the hand were surgically removed, the dystonic symptoms gradually disappeared after a long learning process. This demonstrated that, at least in some cases, control may be relearned and normalised after removal of peripheral movement disturbances [54]

This leads to the following two recommendations:

a. Analysis of biomechanical constraints in the hands of musicians with and without FHDM in a hand biomechanical laboratory. [54-62]
b. Description of the results of de-connection operations in FHDM in one or more "proof of concept"- case reports (level five), presentation of these results in a retrospective case series (level four) and preferably (prospective) research of the results of operative (peripheral) therapy, followed by (central) motor pattern relearning in FHDM. [56;58;63]

7 General recommendations for the future of Performing Arts Medicine in The Netherlands

To foster Performing Arts Medicine in The Netherlands six areas of activities with and for dancers and musicians can be defined:

1 Specialised patient care and cure, both in occupational medicine and primary care as well as in dedicated, specialised, multidisciplinary medical referral expert-centres, aiming for prevention. Since treatment is predominantly conservative, in the future the most appropriate medical specialities for performing arts medicine of the musculoskeletal system may be PM&R (physical medicine and rehabilitation - 'physiatry') and sports-medicine, although there certainly is a place for any other medical speciality (see definition in chapter 1);
2 Clinical studies and scientific research resulting in publications in specialised journals as MPPA (Medical Problems of Performing Artists) and JDMS (Journal for Dance Medicine and Science);
3 Education of medical students (ideally as an integral part of the curriculum), and of physicians and allied healthcare-providers, to stimulate awareness for a different approach to the medical problems of dancers and musicians;
4 Prevention of musculoskeletal complaints in dancers and musicians by teaching the performing artists themselves, especially dance- and music-teachers;
5 Support of and by the Dutch Performing Arts Medicine Association (NVDMG), a dedicated medical scientific association for exchange of expertise, networking, and cooperation amongst individual healthcare providers, institutions and clinics in Performing Arts Medicine, as well as non-financial collaboration with other national and international Performing Arts Medicine Associations;
6 Public relations and publicity to increase and maintain awareness for Performing Arts Medicine.

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Tenor saxophone with support hook

Testing muscle power of peroneus brevis in a dancers' foot

APPENDIX (14-19)

- Summary
- Nederlandse samenvatting
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- Biography
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14 Summary

14

Summary

In chapter one a general introduction is given of Performing Arts Medicine. Since Performing Arts Medicine is a relative young sub-specialty in The Netherlands, a concise historical overview deserves a place in chapter two. This includes a short background of the Medical Centre for Dancers and Musicians (MCDM) in the Haaglanden Medical Centre (HMC) in The Hague, The Netherlands, and the introduction of "PASSION-MD", a 25 years cohort study containing the clinical data of the thousands of dancer- and musician-patients consulting the MCDM since 1993.

The thesis is written in four parts:
In Part 1 orthopaedic Performing Arts Medicine, limited to dancers and musicians and from an orthopaedic perspective, is introduced with general ideas and some specific thoughts about aetiology, prevention, rehabilitation, and conservative treatment.
In Part 2 the results of treatment of limited and painful relevé in dancers due to posterior ankle impingement syndrome (PAIS) and flexor hallucis longus (FHL) tendinopathy are studied.
In Part 3 limited and painful relevé in dancers, due to some structural deformities and specific, miscellaneous and rare forefoot and tarsal conditions, is discussed (Freiberg's disease, accessory navicular and tarsal coalitions) .
Part 4 contains a general discussion, guidelines for clinical studies in dancers and musicians, suggestions for future research and general recommendations for Performing Arts Medicine in The Netherlands .

Part 1

In chapter three an overview of Dance Medicine and Musicians' Medicine is given from an orthopaedic perspective. Causes and treatment of injuries in dancers are explained. As a general principle the physician must respect the passion of the dancer and avoid the advice to stop dancing. Making the diagnosis in musicians' injuries is quite often only possible by examining the patient while playing his or her musical instrument. Extensive explanation, advice, and relative rest supported by mental practice are effective in overuse injuries in musicians.

The subject of chapter four is prevention and rehabilitation of complaints in musicians and dancers. The physical and psychological problems that can befall performing artists are summarised and an insight into their prevention is provided. The second half of this chapter offers insights in dance specific graded rehabilitation and access to a dance-specific structured rehabilitation program.

Chapter five focusses on (orthopaedic) dance medicine, studying and describing aspects of aetiology of common dance injuries. The incidence of symptomatic hyperpronation resulting in prescription for orthotics was 30% in a retrospective study of 2,427 dancers' charts in the Medical Centre for Dancers and Musicians.
In a prospective study among 24 new dancer-patients with possibly hyperpronation-related symptoms, the clinical severity of hyperpronation was linearly related to the calcaneal angle . It was concluded that grading the clinical severity of a dancer's hyperpronation is reliable. Healthcare providers working with dancers should be aware of the presence of hyperpronation, its relation to compensatory turnout techniques, and association with injuries in the foot, ankle, knee, hip, and low back. The most common related diagnosis was patellofemoral pain.

Chapter six concentrates on aspects of conservative treatment in dancers. The usage and effectiveness of orthotics in the management of symptomatic hyperpronation among dancers was investigated in a prospective cohort study of 24 consecutive dancer-patients who were prescribed orthotics for new symptoms related to hyperpronation. Orthotics were found to decrease the medial longitudinal arch angle (i.e. correction of hyperpronation) significantly during static stance with the orthotic in place and give a 26% decrease in pain from the day of orthotics prescription to follow-up. In a retrospective study among 105 participating dancers 67% wore orthotics at the time of follow-up for six days per week and 7.5 hours per day. It is concluded that the dancers in this study demonstrated a high rate of compliance in obtaining and wearing their orthotics and experienced a significant decrease in pain.

Part 2

The subject of part two is the result of treatment of limited and painful relevé in dancers due to posterior ankle impingement syndrome (PAIS or dancer's heel) and / or flexor hallucis longus (FHL) tendinopathy (dancer's tendinitis).

Dancing on pointe and relevé require extreme plantar flexion of the talo-crural joint and may lead to PAIS. PAIS is a painful, usually limited plantar flexion of the ankle joint, due to soft tissue impingement or a bony impediment. PAIS often coincides with FHL tendinopathy behind the medial malleolus. Both injuries are common in dancers and can appear in isolation as well.
In persistent complaints the bony impediment is removed, the tunnel of the FHL tendon is released, or a combination of these procedures is performed by open surgery.

Chapter seven is a systematic search, which was undertaken in October, 2016, to evaluate the results of conservative and operative treatment (both open and endoscopic) of PAIS and

FHL tendinopathy in dancers. Twenty-seven retrospective studies with levels of evidence four and five reported the results of operative treatment in 376 ankles in 324 dancers. Both open (n = 344) and endoscopic (n = 32) procedures were effective and safe and there was no difference between both groups in final outcome or mean time to return to dance. However the endoscopic procedure has been studied in too few dancers to allow any evidence-based recommendations.

Isolated PAIS, PAIS combined with FHL tendinopathy and isolated FHL injuries seem different pathological entities, and more research, preferably with a prospective design and including dance-specific baseline characteristics and outcome scores, is needed to:

- find out in which cases early operative management should be considered or avoided,
- define the place of endoscopic surgery of PAIS and FHL tendinopathy in dancers and
- predict which pathology implicates worse outcomes or delay in return to dance.

Only six publications reported the results of conservative treatment in 33 ankles of 28 dancers, not allowing any evidence-based recommendations.

Chapter eight presents the results of open surgery. Outcomes of treatment by open surgery for PAIS and FHL tendinopathy have been described in small series of dancers only. We extracted data from clinical files and operative reports of the Medical Centre for Dancers and Musicians and defined success rate as an outcome score based on patient satisfaction extracted from the clinical files at the date of discharge from outpatient follow-up. Until October 2016, 148 dancers underwent 190 open procedures for PAIS, FHL, or a combination. In 91% of cases patients reported a "better" or "much better" postoperative outcome. It was concluded that the open surgical treatment of PAIS and FHL tendinopathy in dancers has a high success-rate, and can be considered a successful standard operative approach in dancers.

In chapter nine the open and the endoscopic approaches for the operative treatment of PAIS and FHL tendinopathy in dancers were compared. In 2000 an endoscopic surgical technique was introduced. To date there is no evidence of the superiority of the open or the endoscopic surgical technique for the treatment of PAIS and FHL tendinopathy in dancers. We compared the first 20 consecutive open procedures with the first 19 consecutive endoscopic procedures in dancers only, all operated by the author. The direct postoperative morbidity in the endoscopic group was less favourable. Although the two small groups of dancers, the retrospective character of this descriptive cohort study, and several limitations did not allow firm conclusions or statistical analysis of subgroups, in this study the open approach seemed to be better than the endoscopic approach in the surgical treatment of PAIS and FHL tendinopathy in dancers. It

was concluded that more research is needed to determine the place of endoscopic surgery in the surgical treatment of PAIS and FHL tendinopathy in dancers.

Part 3

Chapter 10 draws attention to Freiberg's disease in dancers. Freiberg's disease is an osteonecrosis of the second metatarsal head, which can severely limit a dancer's relevé. Previously published reports of successful surgical outcomes would, for a dancer, result in an unacceptable loss of dorsiflexion of the second metatarso-phalangeal joint. This first case report of Freiberg's disease in a dancer serves to discuss the orthopaedic and artistic implications of managing the disease in a young, active, adolescent dancer. A new surgical treatment involving modification of Mann's cheilectomy, normally used for hallux rigidus, is presented. The operation corrected the patient's pain, completely normalised the aberrant relevé, allowed her to resume dance training within three weeks, and return to full dance activity within three months.

The subject of chapter 11 is tarsal coalitions in dancers. Tarsal coalitions, a fusion between two or more bones of the tarsus, are a rare entity in dancers and may easily be missed. We describe the presentation, types, and treatment of tarsal coalitions in seven dancers diagnosed in the MCDM between 2008 and 2011. The presenting complaints include a limited and painful relevé. Physical examination reveals a stiff subtalar joint in all cases. In all, six of our dancers with a tarsal coalition were able to continue dancing. Treatment in dancers depends on the type and extent of the coalition. In calcaneo-navicular coalition early resection of the bar is our treatment of choice, based on historic literature and our success with three patients. In our opinion the only option for talo-calcaneal coalition in dancers is conservative management. We recommend to perform the simple "heel-tip test" in every dance-screening.

In chapter 12 the accessory navicular in dancers is studied. The accessory navicular, or os tibiale externum, is an accessory bone on the medial side of the navicular of the foot at the insertion of the posterior tibial tendon. It can cause obvious hyperpronation, medial foot pain, and a limited and painful relevé in dancers. Six dancers (10 feet) were treated in the MCDM for a symptomatic accessory navicular Type II. Five of them (eight feet) underwent surgery, two unilaterally and three bilaterally (at the same time). All five had an excellent result. Simple excision of a symptomatic accessory navicular Type II seems to be a good choice in dancers.

Part 4

Chapter 13 contains the general discussion and gives future perspectives and recommendations. Performing Arts Medicine in The Netherlands is a young sub-specialty and is slowly progressing through the different levels of Evidence Based Medicine. This thesis aims to add some pieces of clinical knowledge and experience to this exciting field.
After explaining some treatment strategies used in the MCDM, including a stepped care - approach used in the chronic, overuse-type injuries, some conclusions of the different chapters are summarized.
Insufficient description of dance related base line characteristics and the inconsistent use of different outcome scores, as encountered in most studies found in the systematic review, prompted the author to formulate guidelines for clinical studies in dance and musicians' medicine, including a proposal for seven standardized levels of Return to dance (RtD), a qualitative functional outcome measure, universally applicable to all dance forms (not only ballet).
The research presented in the different chapters of this thesis made clear how clinical research still has to be developed in orthopaedic dance-medicine, and probably in performing arts medicine in general. Several research questions arise from the articles in this thesis. For that matter, additional research on the painful and limited relevé in dancers due to forefoot problems, like hallux rigidus and sesamoid injuries. Clinical research within the PASSION-MD database (as described in chapter two) is approved by an independent ethics committee and is available for evaluation by clinical researchers in Performing Arts Medicine.
In general clinical (comparative) cohort studies are recommended with dance- or music-specific baseline characteristics, which have to be succinctly defined in order to reduce heterogeneity of the diagnosis, but also are in need of validated functional, dance- resp. music-specific outcome scores in order to compare treatment strategies across patient groups but also internationally. Nowadays several young scientists are doing clinical research in different fields of Performing Arts Medicine in The Netherlands, hopefully resulting in PhD dissertations in the near future.

To foster Performing Arts Medicine in The Netherlands attention must be given to specialised healthcare and prevention for dancers and musicians, clinical studies and scientific research, education, training and stimulating awareness, public relations and close cooperation with the Dutch Performing Arts Medicine Association (NVDMG).

15

Nederlandse samenvatting

15

Nederlandse samenvatting

Het onderwerp van deze dissertatie is Dans- en Muziekgeneeskunde (*Performing Arts Medicine*) vanuit een persoonlijk, orthopaedisch perspectief, gebaseerd op 25 jaar ervaring in het Medisch Centrum voor Dansers en Musici (MCDM). Het onderwerp wordt zowel in algemene zin behandeld, als toegespitst op enkele typische dansblessures: een pijnlijk en beperkt relevé bij dansers (zie figuur 1) door verschillende oorzaken.

Figuur 1: relevé

Dans en Muziekgeneeskunde richt zich op de preventie, diagnostiek en behandeling van de aandoeningen, somatisch dan wel psychisch, die een rol spelen bij het dansen respectievelijk musiceren, alsmede op het wetenschappelijk onderzoek van die aandoeningen en van de gezonde functies bij dansers en musici. [i] Het gaat hierbij om blessures en aandoeningen die ontstaan (zijn) door - of hinderen bij - het dansen resp. musiceren.

Orthopedie is het medisch specialisme dat zich bezighoudt met (blessures van) het steun- en bewegingsapparaat: botten, spieren, gewrichten, pezen en banden, alsmede de structuren (o.a. zenuwen) die daardoor afgekneld kunnen worden.

[i] Zie: www.nvdmg.org

Dansers en Musici vormen een bijzondere en uitdagende subgroep van orthopedische patiënten, want een minimale blessure kan al grote impact hebben, zowel lichamelijk, psychisch, sociaal-economisch als artistiek. Dansers en musici hebben hoge verwachtingen van het genezingsproces en zijn mede daardoor veeleisende patiënten, waaraan veel tijd moet worden besteed.

Er zijn vier redenen waarom dansers en musici op de polikliniek veel tijd nodig hebben:

1 Specifieke dans- en muziek-blessures vereisen specifieke dans- en muziek-kennis en dito *extra* onderzoek.
2 Ogenschijnlijk minimale blessures vereisen een maximale anamnese en lichamelijk onderzoek.
3 De behandeling is bijna altijd conservatief: minder opereren betekent meer uitleg.
4 De benadering van dansers en musici als patiënt vereist een bijzondere attitude van de medisch specialist met respect en empathie voor de passie van de uitvoerende kunstenaar.

De specifieke medische problemen van dansers en musici worden door zorgverleners dikwijls niet voldoende herkend of ingeschat. De behandeling is dan *"..weliswaar naar professionele maatstaven adequaat, maar met te weinig oog voor de emotionele en functionele aspecten van de uitvoerende kunstenaar."* [ii] Dit vormt de legitimatie van de Dans- en Muziekgeneeskunde.

Zowel bij dansers als bij musici geldt bij uitstek dat voorkomen beter is dan genezen: preventie is het ultieme doel, liefst vóór een blessure optreedt (primaire preventie). Minstens even belangrijk is om te voorkómen dat een beginnende blessure verergert (secundaire preventie) of een genezen blessure recidiveert (tertiaire preventie).
Bij de meeste orthopedische blessures van dansers en musici is de behandeling conservatief. Belangrijk onderdeel daarbij, met name bij chronische, overbelastings-blessures, is een 'stappenplan'-benadering: eerst wordt een zorgvuldige medische diagnose gesteld en uitleg gegeven over het ontstaan en voorkómen van de klachten. Aansluitend volgt in het algemeen eerst niet-invasieve conservatieve behandeling gedurende tenminste zes weken. In deze fase wordt niet alleen gebruik gemaakt van spalken, steunzolen, medicijnen en paramedische behandeling, maar ook van dans- en muziek-specifieke revalidatie protocollen.

[ii] Dr.Olaf S.van Hees, Beleidsnota Gezondheidszorg voor de Kunsten, 1991

Bij onvoldoende verbetering volgt pas daarna invasieve conservatieve behandeling (injecties) of - indien mogelijk en geïndiceerd - operatieve behandeling.
Hoewel er wat overlap is met *artistieke sporten*, komen sommige voet- en enkel-posities en bewegingen uitsluitend voor bij dans en dan in het bijzonder bij ballet. Daarom zijn bepaalde blessures ook eigenaardig voor dansers. Dat heeft als consequentie dat de resultaten van behandeling van ogenschijnlijk dezelfde orthopedische blessures bij sporters niet zomaar geëxtrapoleerd mogen worden naar dansers en exclusief in dansers bestudeerd moeten worden. Dit zelfde principe is op musici van toepassing.

Omdat de Dans- en Muziekgeneeskunde in Nederland een nog jong sub-specialisme is, mag een beknopt historisch overzicht van de ontwikkeling van dit aandachtsgebied in ons land niet ontbreken. Het staat in hoofdstuk 2 en is geschreven vanuit een persoonlijk, orthopedisch perspectief. Uiteraard bevat het achtergrond informatie over het (ontstaan van het) MCDM in het Haaglanden Medisch Centrum (HMC) in Den Haag en de introductie van 'PASSION-MD', een database met de klinische gegevens van de duizenden dans- en muziek-patiënten, die het MCDM hebben geconsulteerd sinds 1993.

De doelen van dit promotieonderzoek zijn:
1 Vergroten van het bewustzijn voor de Dans- en Muziekgeneeskunde;
2 Evalueren van de behandelresultaten van een pijnlijk en beperkt relevé bij dansers door achterste enkel-problemen;
3 Bestuderen van enkele andere specifieke voetafwijkingen als oorzaken van een pijnlijk en beperkt relevé bij dansers;
4 Bespreking van de bevindingen, definiëren van gebieden voor toekomstig onderzoek, alsmede het geven van een historisch overzicht en toekomst perspectief van de Dans- en Muziekgeneeskunde in Nederland.

In Deel 1, bestaande uit de hoofdstukken 3 - 6, worden de orthopedische aspecten van Dans- en Muziekgeneeskunde geïntroduceerd met algemene ideeën en enkele specifieke gedachten over het ontstaan (etiologie), het voorkómen (preventie), het herstel (revalidatie) en de conservatieve (dus niet-operatieve) behandeling.

In **hoofdstuk 3** worden oorzaken en behandelprincipes van blessures van het steun- en bewegingsapparaat bij dansers en musici uitgelegd. Belangrijk uitgangspunt is dat de behandelende arts respect en empathie toont voor de passie van de uitvoerende kunstenaar. Bij beide groepen is functioneel onderzoek essentieel: dansers worden onderzocht in de

verschillende dansposities en bij blessures van musici is het stellen van de diagnose vaak alleen mogelijk door de musicus tijdens het bespelen van zijn of haar instrument te onderzoeken. Wil men het vertrouwen van een danser of danseres behouden, dan moet men nooit adviseren om te stoppen met dansen. Bij overbelastings-blessures bij musici zijn uitgebreide uitleg, gericht advies met muziekkennis van zaken, frequente micropauzes en relatieve rust, ondersteund door mentaal studeren (visualiseren) effectief.

Hoofdstuk 4 gaat over preventie en revalidatie van klachten bij musici en dansers. De lichamelijke en psychische problemen die uitvoerende kunstenaars kunnen oplopen worden opgesomd en inzicht in het voorkómen van deze blessures wordt gepresenteerd.
In de tweede helft van dit hoofdstuk wordt dans-specifieke revalidatie met geleidelijk toenemende belasting en impact (graded activity) besproken. Tevens wordt een dans-specifiek, gestructureerd revalidatie-programma verstrekt.

Hoofdstuk 5 behandelt *hyperpronatie*, het 'inrollen' van de voeten, als mogelijke (bijkomende) oorzaak van gebruikelijke dansblessures.
Bij het retrospectief bestuderen van de patiëntengegevens van 2427 dansers in het MCDM bleek het percentage symptomatische hyperpronatie, resulterend in het voorschrijven van harde, orthopaedische steunzolen, 30% te zijn.
In een prospectief onderzoek onder 24 nieuwe dans-patiënten met mogelijk symptomatische hyperpronatie bleek mijn klinische inschatting van de ernst van hyperpronatie recht evenredig met de calcaneus hoek; dat is de stand van het hielbeen ten opzichte van de lengte as van het onderbeen, van achter gezien. De conclusie was enerzijds dat deze klinische inschatting betrouwbaar is, anderzijds dat medici en paramedici alert moeten zijn op de aanwezigheid van hyperpronatie bij dansers en de relatie daarvan met compensatie mechanismen van de heup uitdraai en de samenhang met blessures van de voet, enkel, knie, heup en lage rug. De meest voorkomende met hyperpronatie samenhangende diagnose is patellofemorale pijn, pijn rondom of achter de knieschijven.

In **hoofdstuk 6** worden het gebruik en de effectiviteit van harde, orthopedische steunzolen als behandeling van symptomatische hyperpronatie bij dansers bestudeerd.
In een prospectieve cohort studie van 24 opeenvolgende dans-patiënten, die steunzolen voorgeschreven hadden gekregen voor nieuwe symptomen gerelateerd aan hyperpronatie, bleken de gebruikte steunzolen de hyperpronatie aanzienlijk te verbeteren tijdens statische belasting (op de steunzolen) en 26% pijn vermindering te geven vanaf de dag van voorschrijven van de steunzolen tot het moment van follow-up.

In een retrospectieve studie onder 105 deelnemende dansers droeg 67% de steunzolen nog gedurende zes dagen per week en 7,5 uur per dag na gemiddeld drie jaar.
De conclusie luidde dat de dansers in dit onderzoek zeer gemotiveerd waren om de voorgeschreven steunzolen daadwerkelijk te laten maken en te dragen, met een aanzienlijke pijnvermindering als gevolg.

In Deel 2, de hoofdstukken 7 - 9, worden de behandelresultaten van een pijnlijk en beperkt *relevé* (zie figuur 1) bij dansers ten gevolge van blessures aan de achterzijde van de enkel bestudeerd en uitgelegd.

Figuur 2: op spitzen

Relevé en dansen op *spitzen* (zie figuur 2) vereisen een extreme strekking van de enkels. Als er daarbij sprake is van inklemming van weke delen of een stukje bot aan de achter-buitenzijde van de enkel kan dat leiden tot een pijnlijk en beperkt relevé en wordt dat *Posterior Ankle Impingement Syndrome (PAIS)* genoemd.

PAIS gaat vaak samen met een peesontsteking *(tendinopathie)* van de lange buigpees naar de grote teen, de *Flexor Hallucis Longus (FHL)*. Deze pees verloopt aan de binnen-achterzijde van de enkel bij de achillespees. Beide aandoeningen, die ook los van elkaar voorkomen, zijn typische, frequent voorkomende dansblessures en worden daarom ook wel dansers-hiel en dansers-peesontsteking *(dancer's heel & dancer's tendinitis)* genoemd.

Bij hardnekkige klachten wordt een inklemmend botfragment operatief verwijderd en / of de peesschede van de FHL gekliefd.

Hoofdstuk 7 beschrijft de bevindingen van een systematisch verricht literatuuronderzoek in oktober 2016 om de resultaten van behandeling van PAIS en/of FHL tendinopathie bij dansers te evalueren. Zevenentwintig retrospectieve onderzoeken met een laag bewijs niveau (levels of evidence vier en vijf) beschreven de resultaten van operatieve behandeling van 376 enkels bij 324 dansers. Zowel de open operatie (n = 344) als behandeling via een kijkoperatie (n = 32) bij dansers bleken effectief (89% goed en uitstekend) en veilig (0,8% ernstige complicaties) en er waren geen verschillen tussen beide groepen in eindresultaat of terugkeer naar dans (gemiddeld 11 weken). Er waren te weinig dansers behandeld via een kijkoperatie om daar aanbevelingen op te baseren.
De indruk bestaat dat geïsoleerde PAIS, PAIS in combinatie met FHL tendinopathie en geïsoleerde FHL blessures bij dansers verschillende pathologische eenheden zijn.
Er is dan ook meer onderzoek nodig, bij voorkeur prospectief en met dans-specifieke bevindingen, om te bepalen:

- wanneer vroege operatieve behandeling overwogen of juist vermeden moet worden
- wat de plaats is van een kijkoperatie bij de behandeling van deze blessures bij dansers
- welke pathologie slechtere uitkomsten of vertraging in terugkeer naar dans impliceert.

Slechts zes publicaties beschreven de resultaten van conservatieve behandeling van 33 enkels bij 28 dansers en daar waren geen zinnige *(evidence-based)* conclusies uit te trekken.

In hoofdstuk 8 worden de resultaten van operatieve behandeling van PAIS en/of FHL tendinopathie bij dansers via de traditionele, open techniek beschreven. Tot oktober 2016 werden door mij in het MCDM bij 148 dansers 190 open ingrepen gedaan voor PAIS, FHL tendinopathie, of een combinatie van die twee. Aan de hand van de klinische gegevens en de mate van tevredenheid van deze danser-patiënten, zoals opgetekend in de status op het moment van ontslag uit de poliklinische na-controles, werd de uitkomstscore bepaald. In 91% van de gevallen rapporteerden patiënten een "betere" of "veel betere" postoperatieve uitkomst. De conclusie van dit onderzoek luidde dan ook dat de open chirurgische behandeling van PAIS en FHL tendinopathie in dansers een hoog succes percentage kent en beschouwd kan worden als een succesvolle standaard operatieve benadering bij dansers.

In 2000 werd een kijkoperatie techniek (endoscopie) voor de behandeling van achterste enkel blessures geïntroduceerd. Omdat er tot op heden geen bewijs is voor de superioriteit van één van beide technieken bij dansers, worden in **hoofdstuk 9** de open en de endoscopische operatieve benadering voor de behandeling van PAIS en/of FHL tendinopathie bij dansers, vergeleken in de eerste 20 opeenvolgende open procedures en de eerste 19 opeenvolgende endoscopische procedures, uitsluitend bij dansers en geopereerd door mijzelf. Het direct

postoperatieve herstel in de endoscopische groep was minder gunstig. Omdat het twee kleine groepen dansers betreft in een beschrijvend retrospectief onderzoek, zijn harde conclusies en statistische analyses van subgroepen niet mogelijk. In dit onderzoek lijkt de open benadering beter dan de endoscopische voor de behandeling van PAIS en/of FHL tendinopathie bij dansers. Nadere plaatsbepaling van de endoscopische techniek bij dansers vereist dus meer onderzoek.

In Deel 3, de hoofdstukken 10 - 12, worden drie minder vaak voorkomende oorzaken van een pijnlijk en beperkt relevé bij dansers besproken: *de ziekte van Freiberg, tarsale coalities* en het *os tibiale externum.*

De *ziekte van Freiberg* is het onderwerp van **hoofdstuk 10**. Door een doorbloedingsstoornis van het bot *(osteonecrose)* wordt het kopje van het tweede middenvoetsbeentje aangetast en ontstaat een misvorming van het basisgewrichtje van de tweede teen. Het treedt vooral op bij jonge, actieve, opgroeiende mensen en kan bij dansers een pijnlijk en beperkt *relevé* veroorzaken. In de literatuur worden 'succesvolle' operaties beschreven, die echter voor een danser een onacceptabel verlies van dorsoflexie en dus van relevé zouden betekenen. Ik presenteer aan de hand van een *case report* (de beschrijving van de ziektegeschiedenis van één danseres) de orthopedische en artistieke consequenties én een mogelijke, nieuwe operatieve behandeling van deze ziekte voor dansers, namelijk een gemodificeerde 'Mann-cheilectomie', een aanpassing van een operatie die ik normaal gesproken gebruik bij hallux rigidus (stijve grote teen) bij dansers. Deze ingreep verloste de danseres in kwestie van haar pijn en herstelde haar normale relevé. Ze kon binnen drie weken haar danstraining hervatten en binnen drie maanden weer voluit dansen.

Een tarsale coalitie is een aangeboren, abnormale verbinding tussen twee of meer voetwortelbeentjes, die eigenlijk niet aan elkaar vast horen te zitten. Ze komen maar zelden voor bij dansers en worden makkelijk gemist. In **hoofdstuk 11** beschrijf ik het klachtenbeeld, de verschillende types en de behandeling van tarsale coalities bij zeven dansers, die ik tussen 2008 en 2011 voor deze diagnose behandelde in het MCDM. Eén van de klachten bij dansers is een pijnlijk en beperkt relevé. Bij lichamelijk onderzoek is er in alle gevallen een stijf onderste spronggewricht bij de 'kieptest'. Zes van deze zeven dansers met zulk een coalitie waren in staat om door te gaan met dansen.

De behandeling van een coalitie hangt af van het type en de uitgebreidheid van de verbinding. Afgaand op de literatuur en mijn behandelresultaten, is bij sommige types (calcaneo-naviculaire coalitie) operatieve verwijdering van de benige verbinding op jonge leeftijd de beste keuze,

maar bij een ander veelvoorkomend type (talocalcaneaire coalitie) is conservatieve behandeling de enige optie. Mijn advies is om bij elke dans-screening een 'kieptest' te doen.

In **hoofdstuk 12** beschrijf ik het *os tibiale externum*, in het engels: accessory navicular genaamd. Dit is een extra botje of te ver uitstekende botpunt aan de binnenzijde van de voetboog in de aanhechting van de aldaar verlopende *(tibialis posterior)* pees. Het geeft een opvallende, ernstiger lijkende hyperpronatie, pijn aan de binnenzijde van de voet en bij dansers een pijnlijk en beperkt relevé. Ik behandelde zes dansers (tien voeten) in het MCDM aan een symptomatisch os tibiale externum. Vijf van hen (acht voeten) opereerde ik, waarvan drie dansers aan beide voeten tegelijk. Alle vijf hadden een uitstekend resultaat. Eenvoudige excisie van een symptomatisch os tibiale externum lijkt een goede keuze bij dansers.

Deel 4, hoofdstuk 13, bevat de algemene discussie en conclusies, suggesties voor verder klinisch onderzoek van het steun- en bewegingsapparaat bij dansers en musici en aanbevelingen voor de toekomst van de Dans- en Muziekgeneeskunde, een nog jong aandachtsgebied in Nederland, dat zich langzaam omhoog werkt langs de wetenschappelijke Evidence Based Medicine ladder. Deze dissertatie hoopt daaraan een bijdrage te leveren. Een belangrijke en teleurstellende bevinding van het uitgebreide literatuur onderzoek in hoofdstuk 7 is, dat bij klinisch wetenschappelijk onderzoek de dans-specifieke gegevens onvoldoende of niet vermeld worden en dat er zeer verschillende uitkomstmaten worden gebruikt, waarbij het doel van de behandeling, terugkeer naar de gewenste dansactiviteit (*Return to dance* - RtD), niet of zeer wisselend omschreven wordt. Om toekomstig klinisch onderzoek in de orthopedische dansgeneeskunde te faciliteren, heb ik richtlijnen opgesteld, waaraan zulk onderzoek moet voldoen, inclusief een voorstel voor zeven gestandaardiseerde niveaus van terugkeer naar dans (RtD), een kwalitatieve, functionele uitkomstmaat, die universeel toepasbaar is op alle vormen en stijlen van dans en dus niet alleen ballet. Daarbij ligt achtereenvolgens de nadruk op het herwinnen van mobiliteit, kracht, uithoudings-vermogen, timing / coördinatie en zelfvertrouwen, aan de hand van toenemende belasting en impact (zie hoofdstuk 13, paragraaf 2, tabel 2).

Elk wetenschappelijk onderzoek geeft aanleiding tot nieuw onderzoek en deze dissertatie maakt duidelijk hoeveel klinisch onderzoek nog gedaan moet worden in de orthopedische dansgeneeskunde. Daarom worden in deze dissertatie een aantal nieuwe onderzoek-onderwerpen genoemd, onder andere suggesties voor aanvullend onderzoek naar andere oorzaken van een pijnlijk en beperkt relevé bij dansers, zoals *hallux rigidus* (stijve grote teen) en blessures van de *ossa sesamoïdea* (twee kleine botjes onder het basisgewricht van de grote teen).

Omdat het MCDM daartoe ruime mogelijkheden biedt, geef ik nog een aantal aanvullende suggesties voor ander toekomstig klinisch, retrospectief onderzoek bij dansers en musici, middels 'PASSION-MD'. Deze hierboven beschreven database met, deels prospectief verzamelde, klinische gegevens van duizenden dans- en muziek-patiënten, kan wellicht in de toekomst verder wetenschappelijk onderzoek van de Dans- en Muziekgeneeskunde initiëren. Voor gebruik van deze database bestaat al toestemming van de Medisch Ethische Toetsings Commissie (METC- Zuid Holland).
Om verschillende conservatieve en operatieve behandelmogelijkheden bij dansers en musici te vergelijken, heeft, indien mogelijk, prospectief, gerandomiseerd klinisch onderzoek de voorkeur, met een duidelijke beschrijving van de dans- of muziek-specifieke karakteristieken van de onderzochte populatie en het gebruik van gevalideerde functionele dans- of muziek-specifieke uitkomst-scores en, bij voorkeur gestandaardiseerde definities van de eindpunten *return to dance*, resp. *return to music*.

Om de Dans- en Muziekgeneeskunde in Nederland verder te ontwikkelen moet aandacht gegeven worden aan vijf verschillende terreinen:

1 patiëntenzorg voor dansers en musici,
2 preventie door instructie van dansers en musici zelf, met name van docenten,
3 onderzoek, zowel klinisch als basaal wetenschappelijk, ondersteund door de wetenschappelijke vereniging NVDMG,
4 onderwijs aan medisch studenten, artsen in opleiding tot medisch specialist (aios) van de steun- en bewegingsapparaat specialismen (i.e. orthopeed, reumatoloog, revalidatiearts en sportarts), huisartsen en andere medisch specialisten,
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Boni Rietveld, Aerdenhout, 12-6-2017

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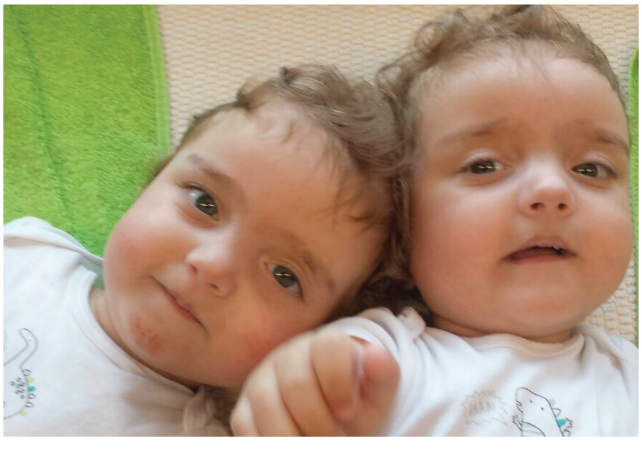
A.B.M.(Boni) Rietveld, portrait by medical photographer Michel Groen of The Hague Medical Centre (HMC)

A.B.M.(Boni) Rietveld, portrait by medical photographer George Patho of The Hague Medical Centre (HMC)



Alexander B.M. Groen and Valentijn H.J. Groen, born on May 3rd, 2016 Sydney, Australia

17 Biography

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Biography

Boni Rietveld (1952, Rotterdam, The Netherlands) is a graduate of the Royal Conservatoire for Music in The Hague (trumpet, 1976), of Leiden University Medical Centre (MD, 1978) and a board-certified orthopaedic surgeon (Leiden, 1987). He specialised in dancers' and musicians' injuries, a.o. with W.G.Hamilton, orthopaedic surgeon of the New York City Ballet Company.

In 1988 he was appointed orthopaedic surgeon of the Nederlands Dans Theater. This activity merged into the Medical Centre for Dancers and Musicians (MCDM), which he established in The Hague Medical Centre (HMC) on April 1st, 1993, and where he has worked ever since.

Mr.Rietveld is involved full time in Performing Arts Medicine as a clinician, researcher and teacher, and in the international organisational Performing Arts Medicine field. He is a member of the *'Kuratorium'* of Tanz Medizin Deutschland (tamed), past president (2007-2009) of the International Association for Dance Medicine & Science (IADMS), and since 2005 president of the Dutch Performing Arts Medicine Association - NVDMG (see: www.nvdmg.org).

On March 28th, 2015 the NVDMG celebrated its 10th anniversary with its 15th scientific Symposium *'Genees & Kunst'* ("Medicine & Art") in the University Medical Centre of Rotterdam. On this occasion Rietveld was awarded a royal honour of merit, *'Officer in de Orde van Oranje Nassau',* for his tireless efforts to improve healthcare for dancers and musicians, both nationally and internationally.

He is the author of a chapter on orthopaedic dance- and musicians-medicine in *'Orthopedie',* the Dutch handbook of orthopaedics (3rd edition, 2013) and publishes regularly in medical scientific and popular magazines.

Besides his orthopaedic work he performs and records regularly as a trumpeter. He is married and has two children and identical twin grandsons.

18 Curriculum vitae

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Curriculum vitae

Boni Rietveld (1952 - Rotterdam) haalt in 1970 zijn eindexamen Gymnasium aan het Stedelijk Gymnasium in Haarlem.
Op 24 november 1976 studeert hij af aan het Koninklijk Conservatorium te 's-Gravenhage (hoofdvak trompet bij Theo Laanen en bijvak harp bij Edward Witsenburg).
Op 30 juni 1978 haalt hij zijn artsexamen in Leiden.

Hij vervult zijn dienstplicht bij het Korps Commando Troepen (groene baret) in Roosendaal, blijft actief reservist en gaat in 2012 met eervol ontslag als luitenant-kolonel-arts b.d. (R).

Tijdens en na zijn opleiding orthopaedie in het Academisch Ziekenhuis te Leiden (thans LUMC), specialiseert hij zich in blessures van dansers en musici, o.a. in New York bij William G. Hamilton, M.D., orthopaedisch chirurg van de New York City Ballet Company.
Op 1 mei 1987 wordt hij geregistreerd als orthopaedisch chirurg en volgt hij (tot 1 maart 1989) zijn vader C.F.W.(Kees) Rietveld † op, als orthopaedisch chirurg in het St.Elisabeth's of Groote Gasthuis (thans Spaarne Gasthuis) te Haarlem.

In 1988 wordt hij door Carel Birnie † benoemd tot orthopaedisch chirurg van het Nederlands Dans Theater (NDT) in Den Haag. Zijn werk bij het NDT gaat op in het door hem op 1 april 1993 opgerichte Medisch Centrum voor Dansers en Musici (MCDM) in het Haaglanden Medisch Centrum (HMC Westeinde) te 's-Gravenhage, alwaar hij tot op heden werkzaam is.
Op 1 april 2003 opent HKH Prinses Margriet der Nederlanden de nieuwe polikliniek van het MCDM en in 2018 hoopt het MCDM zijn 25-jarig bestaan te vieren.

Rietveld wijdt zich als orthopaedisch chirurg uitsluitend en fulltime aan dansers en musici, is een veelgevraagd spreker, geeft college aan het LUMC, het AMC en in Frankfurt en publiceert regelmatig.

Hij is mede-oprichter (op 1 april 2005) en voorzitter van de Nederlandse Vereniging voor Dans- en MuziekGeneeskunde (NVDMG) en van 2007 tot 2009 president van de International Association for Dance-Medicine and Science (IADMS).

Op 28 maart 2015 wordt Boni Rietveld benoemd tot Officier in de Orde van Oranje-Nassau, omdat *"door zijn tomeloze inzet de orthopedische zorg voor dansers en musici, nationaal én internationaal, op een uitzonderlijk hoog niveau is gebracht".*

Hij treedt regelmatig op als trompettist, maakt meerdere CD's, is getrouwd met Marijke Nederveen en heeft twee getrouwde kinderen en twee identieke kleinzoons.

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List of publications / Bibliografie

List of publications / Bibliografie

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This includes all scientific publications in which Rietveld ABM is first author or co-author.

a. References nrs. 1-11 are used as chapters in this thesis (in order of appearance).

b. References nrs. 12-31 are peer reviewed scientific publications and bookchapters and nrs. 32-40 are published proceeding of symposia (all in chronological order, most recent first).

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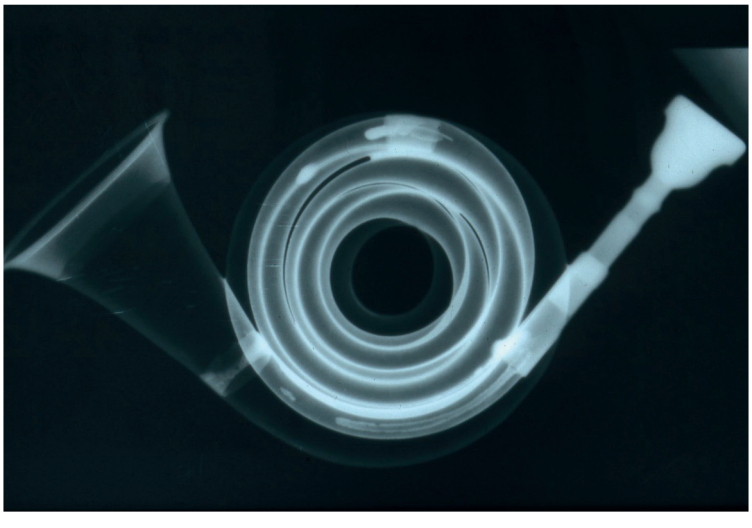
Pocket hunting horn



Radiography of pocket hunting horn

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