Universiteit Leiden
The Netherlands

Dance medicine: risk factors for dancers' musculoskeletal injuries

Kaufmann, J.E.

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Chapter 1

General Introduction

1.1 The Background

For pre-professional, professional as well as amateur dancers, dance is a demanding high-performance activity. It requires great dedication and discipline from the dancers involved. In order to ensure overall wellbeing in the broadest sense, as well as at highest levels of performance, a healthy approach to dance teaching and training is vital. At best, injury-preventive approaches are evidence-based, drawing from biomechanically optimal dance technique and fitness levels which take the individual performing athlete into account.[1] Moreover, to ensure mental and psychological wellbeing, high quality of motivation based on an empowering work climate has shown to be vital.[2, 3]

1.2 Dance Medicine & Dance Science

In order to guide dancers and teachers to healthy training and working experiences dance medicine has evolved over the last decades. Dance medicine is part of performing arts medicine, dedicated to investigate, prevent, treat, and rehabilitate injuries while enhancing performance for all dance styles, genders, and age groups.[4] Dance medicine is sometimes considered to be a sub-discipline of sports medicine, stressing the important aspect of athleticism in this virtuous and demanding art form.[5] While sports medicine and science have a long history[6], a specific focus on dance medicine and dance science has evolved only in the late 20th century. Although, the first publications date back to as early as 1824[7], 1898[8], and 1935[9].

To date, dance medicine and dance science have provided an increasing body of research on several topics essential for injury prevention and performance enhancement of dancers, in which classical ballet is the dance style investigated most intensively.

Among the investigated topics are incidence, prevalence, risks, and causes of musculoskeletal injuries in dancers[10-16] as well as the psychological and financial burden of injuries for all stakeholders involved.[17-19] The importance of evidence based planning and scheduling of training[20-24] and the necessity to regard dancers as performing athletes who are supported and encouraged to train and have optimal dietary intake accordingly[20, 25-27] has received a lot of attention. (Neuro-) psychological aspects such as the prevention of eating disorders[28, 29] as well as the correct handling of pain and injury[30-32], the prevention of fatigue[23, 33] and overtraining[34, 35] have been researched.

1.3 The Important Synergy between Dance Medicine & Dance Pedagogy

In order to have dancers of all ages and all levels of expertise benefit from dance medical research, the proactive implementation of scholarly evidence into dance practice is vital. This bridge between scientific results and practical use on site has been discussed in sports medicine, and the coach or trainer has been described as the most important link for this synergy to be effective. [36-41] The coach's/teacher's motivation, compliance as well as their knowledge to implement evidence-based training methods into practice and thus inspire their athletes' compliance is vital for any injury preventive intervention.[39-42]

In dance or ballet, this role would be the ballet teacher's or ballet master's. Their task, teaching dance and guiding dancers, is also known as dance pedagogy, the art and science of teaching dance to students from early childhood to adulthood.[43] In children and adolescent pre-professional as well as amateur ballet dancers of all ages, the teacher is called dance pedagogue or ballet teacher. In professional ballet dancers, the term "ballet master" is used for the person who trains dancers in their every-day profession.

Repeatedly, the importance of a synergy between dance medicine and dance pedagogy – building dance education on the pillars of science – has been advocated by various authors as the most important solution to bringing dancers in touch with dance medicine in order to prevent their injuries.[44-46]

1.4 The Injury Panorama in Dancers

Injuries to dancers, ballet dancers as well as all dancer who include classical ballet as a major training focus such as modern and contemporary styles, can be acute (traumatic) or chronic (repetitive strain overuse). Acute injuries are linked to an identifiable event and a precise onset[47] during a dancer's performance, rehearsal, or training. Although prevalence and incidence of acute injuries are high in classical ballet, the majority of (ballet) dancers' injuries originate from chronic overuse and thus are non-traumatic in nature.[10] Defined as musculoskeletal complaints or injuries which cannot be linked to a clearly identifiable event or time of onset[47]. These overuse injuries usually have a rather complex etiology involving previous injuries which did not heal properly, overtraining, malnutrition, and a variety of other factors.[12, 48]

While the body of available scientific research on musculoskeletal injuries and prevention in dance medicine and science is increasing, the prevalence, incidence, and risks of these injury in dancers, including amateurs are still high.[11, 15, 17]. A systematic review on articles from 1966 to 2004 on professional ballet dancers' injuries, reported the lifetime prevalence to be ranging from 40% to 84%, with a point prevalence of 74%.[10] In a prospective study period of one season, Allen at al.[11] documented 4.4 injuries per 1000 working hours and a mean of 6.8 injuries in professional dancers. Of those injuries, 64% were overuse injuries. Fredrikson and Clarsen prospectively recorded injuries in another

world renowned ballet company.[49] Within 32 weeks, the average prevalence of injuries was 64%. These prevalences of injuries in ballet dancers are higher than in other elite performers, such as in the Olympics.[49]

Prospective studies in pre-professional adolescent ballet dancers with an average workload between 20 and 35 hours per week have shown high injury risk[17] and prevalence of injuries in the young.[50] With an incidence of 1.42 injuries per adolescent dancer per year and 76% of risk to sustain an injury within only one study year in ballet school, the risk for adolescent ballet dancers is higher than in most other sports.[17] Injury risks and rates increased throughout the three years of pre-professional training.[17] Already in the pre-professional adolescents, overuse injuries are prominent, most of them related to the joints (ankle, knee), as well as bones (predominantly stress fractures).

Further studies highlight the increase of injury risk proportionally to a commonly constant increase of workload throughout the season or school year of ballet dancers.[17, 51, 52] Furthermore, studies stress the risk of repetitive injury due to the high tendency of pre-professional, professional but also amateur ballet dancers and potential pathological changes if symptoms are ignored (i.e. work despite pain caused by an injury instead of treating it).[53-57] Dance science highlights these general aspects of medicine in ballet with respect to training, injuries as well as injury prevention throughout all levels of expertise.

Risk factors for these musculoskeletal injuries are part of ongoing research. Injury etiology and related factors have shown to be complex [58, 59], not only due to the fact that young ballet dancers are taught to dance through pain and injuries, regarding them as an integrating part of their profession.[50, 56] In the very traditional environment of classical

ballet, many aspects have been evaluated and be claimed to be linked to the etiology of injuries.[17, 60] Among them are erroneous dance technique [44, 60], deficits in individual fitness levels and certain, non-evidence based training methods [22, 61], but also the way teachers and ballet masters coach their dancers based on their knowledge and proactive effort to include dance scientific evidence into practice.[62, 63] These aspects will be addressed in this thesis. A short background on these risk aspects which could be associated with musculoskeletal injuries are given in 1.5 through 1.9.

1.5 The Role of Optimal Dance Technique for Injury Prevention

Erroneous dance technique has frequently been researched within the context of dance injuries. Among the many aspects of ballet technique, the technique of maximal leg-external rotation monitored by the hip joint, called “Turnout” or “En Dehors”, can be regarded as the basis of classical ballet technique which all other dance technical aspects but also dance styles such as modern and contemporary, built upon.[64, 65] In traditional approaches, dancers and teachers strive to achieve a turnout-angle of 180° between the two longitudinal axes of both feet (*Figure 1*). While turnout is supposed to be dominated by the hip joint's external rotation, the traditional approach has focused teachers and dancers onto the appearance of the feet. However, such unrealistic goals very often don’t take the dancer’s individual passive osseoligamentous and active myofascial (e.g., muscular endurance, neuromuscular control) capacities into account. There is evidence that even principal dancers display an average turnout angle of 134.6° in both legs.[64] Therefore, in striving for ideal total turnout of 180°, many dancers (have to) force their joints beyond optimal biomechanical abilities, which leads to compensatory movements along the kinetic chain of motion. The association between the dance technique of

“turnout” and ballet dancers’ injuries to the lumbar spine, knee joints, ankle and feet have been investigated throughout various studies [30, 66], but a scholarly conclusion has not yet been drawn.

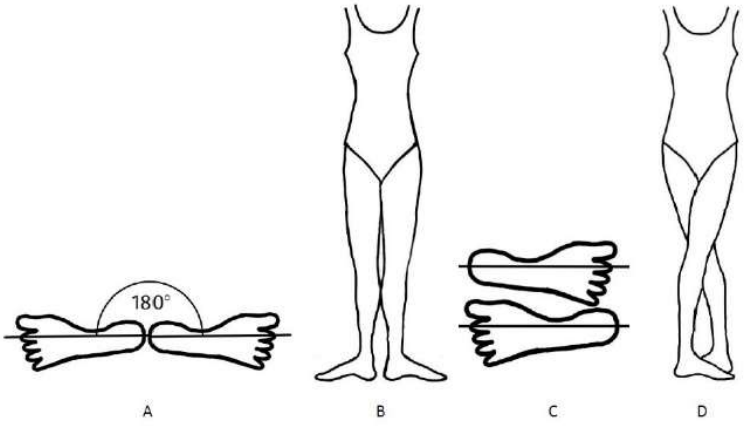

Figure 1: “ideal” functional turnout in 1st (A+B) and 5th (C+D) classical ballet position

1.6 The Role of the Ballet Teacher or Ballet Master for Injury Prevention

As previously introduced, in sports science the coach was identified as the most important person regarding injury prevention in athletes.[39] Not only with respect to implementing injury preventive measures [40, 41], but also for creating a safe motivational climate for such implementation of dance medicine into practice. The latter influences the athlete's learning, performance and overall health in general and also allows dancers to learn how to recognize early symptoms for injury or fatigue and how to deal with those. Such proceedings would include to learn how to deal with pain, to report injuries or complaints immediately, receive diagnosis and subsequent time for healing as well as evidence-based transition training to be ready to take up training again after rehabilitation.[67] Studies showed how negative motivational climates created by teachers were associated with a

negative affective state of dancers, which again affected their perception of wellbeing and performance. Although several studies evaluated the role of teachers'/masters' behavior and knowledge regarding dancers' health [16, 44, 62, 68, 69] as well as the resulting motivational environment associated to dancers' psychological wellbeing [2, 3], the association between teacher behavior and musculoskeletal injuries in dancers has not yet been evaluated. The latter has been found, however, in sports science.[70]

1.7 The Role of Warm-up for Injury Prevention

The workload of classical ballet dancers, especially pre-professionals and professionals, is very high, thus indicating that implementation of injury prevention measures is crucial.[17, 51]

Sports science has identified another aspect of science of training, through which injury prevention can be addressed in athletes: neuromuscular warm-up.[71-76] This type of warming-up in athletes aims at including fitness aspects which are not addressed during regular training of the athlete but were identified as risk factors for injuries such as sport specific strength, strength endurance, or power, as well as dynamic neuromuscular control of leg and arm alignment or core stability.[36, 74, 77-80].

In ballet research, however, neuromuscular warm-up has not been evaluated so far. Furthermore, neither in dance in general nor in classical ballet specifically, the warm-up habits of dancers have been documented in the first place, which would allow a first impression on how warm-up is being dealt with and facilitate future research.

1.8 The Role of Dance Medicine & Dancers Themselves for Injury Prevention

In order to prevent injuries, the nature of their cause needs to be evaluated. A possible method is to include dancers on this evaluation of perceived causes for their musculoskeletal injuries. Hence, dancers can give background information on circumstances leading to their injuries. In addition, asking dancers for their opinion empowers them and creates an awareness for the importance of their musculoskeletal injuries, thus facilitating their proactive compliance for preventive measures and easier implementation into dance practice later on.

Furthermore, no study has specifically aimed at investigating if dance medical research has been implemented into dance practice, first and foremost through the motivation of ballet teachers or ballet masters to base their dance pedagogy on dance medicine. In sports science it was shown that the sports coach's attitude towards injury prevention programs determines whether interventions reach their athletes. As such, dancers are highly depending on their teachers and masters, their knowledge and professional expertise, when trying to prevent injuries. Insight, if dance medicine is implemented is a necessity to be able to develop targeted injury prevention programs.

1.9 The Role of Injury as a Stressor for Injury Etiology & Injury Prevention

Originating from the realms of physics, the term "stress" as a neuropsychophysiological reaction was first described by Hans Seyle.[81-83] If exposed to mental or physical stress, the vegetative nervous system releases glucocorticoids and catecholamines, interacting with immune, cardiovascular, neuronal, and muscular systems.[84] Body adaptation and recovery functions can be negatively affected by intensity and duration of those

physiological and neuropsychological stress responses depending on how a person appraises the severity of a stressor, on their ability to cope with this stressor, and whether they perceive a stressor as an imminent threat to their life or career.[85] Especially chronic stress has been linked to illness[86-89], and in dancers and other athletes, psychosocial stress has been associated with injury risk.[90, 91] However, the injury as such might be regarded as a stressor as well.

In injury-response-models, such as Brewer's[92], it is suggested that injury is first appraised cognitively, followed by an emotional and behavioral response. However, injury responses are depending on the individual. The personality of the injured (e.g., trait anxiety, motivation, hardiness, locus of control), their coping behavior (e.g., coping skills, goal setting), history of stressors (e.g., previous injuries) and perceived social support play important roles.[85, 93, 94] For that matter, and thus highlighting the complexity of injury as well as the individual's neuropsychological appraisal, Mainwaring and colleagues suggested a person-to-situation-model. They described injury-response to be a more complex, multidimensional interaction between factors related to the affected individual and their environment rather than a linear process of events.[95] In Mainwaring's model, the individual's psychological, physical, behavioral and social responses act as moderators, affecting and being affected by intrinsic and extrinsic determinants. Intrinsic factors could be demographics, traits, coping behavior, identity, nutritional aspects, knowledge, or other stressors, while the dance environment, financial situation, social support, dance culture and identity, and treatment can be named as extrinsic factors.[96] As such, Mainwaring's model stresses a holistic approach to injury appraisal and injury rehabilitation.

Dancers show a high prevalence and incidence of injuries for which mental stress has shown to be a risk factor.[48] Since injury is perceived as stressful, threatening careers as well as identities[95, 97, 98], injuries might increase dancers' stress levels and thus their risk for consecutive injury. Moreover, in sports science it has been described that athletes cope better with consecutive injury than with first-time-injury, being more accepting of the injury and less anxious.[99] In dancers, those aspects have not yet been investigated. However, since dancers are known to be working through injury and pain[32, 97], it might be interesting to know if injury could intensify dancers' fear of more severe and/or consecutive injury so much that their stress levels upon second- or further injury are increased instead of lower, as it had been shown in other athletes.

For that matter, we aimed to investigate whether 1) injuries are associated with increased stress levels, and 2) if consecutive injuries are related to higher perceived stress levels than first injury in first-year dance students.

1.10 The Aim of this Thesis

At present, the above-mentioned topics have not specifically been studied. Therefore, this thesis aims to evaluate aspects of the synergy between dance medicine and dance pedagogy with the aim to prevent musculoskeletal injuries in classical ballet dancers and to provide the basis for future research.

As such we investigated some important aspects on the etiology and prevention of ballet dancers' musculoskeletal injuries. Specifically, this thesis looked into aspects which have not yet been studied before, such as warm-up or motivational climate in order to provide the basis for future research. Also we evaluated effects of erroneous dance technique,

the causes that dancers perceived for their injuries and their perceived implementation of dance medicine into dance practice by their ballet master or ballet teacher.

For that purpose, this thesis is based on four studies which all are the first of their kind to investigate the respective topic in dance medicine and science.

1) A systematic literature review is performed to investigate the association between the dance technique of “turnout” and musculoskeletal injuries in ballet dancers, studying the various approaches that have been conducted over the previous decades.

2) The association between musculoskeletal injuries and motivational climate created by the ballet teacher or ballet master is researched.

3) A documentation of warm-up habits in ballet dancers is provided. Furthermore, the association between warm-up routines and musculoskeletal injuries is investigated.

4) Dancers’ perceptions of causes for their injuries and their teachers'/masters' level of implementation of preventive dance medicine is investigated, asking which factors dancers perceive to be important when it comes to their injuries and injury prevention.

5) A prospective longitudinal study investigated the role of injury as a stressor for dancers. The study assessed first and consecutive injuries and compared stress levels during injury to baseline stress levels dancers had reported before they entered an educational dance program at a university for arts and dance.

1.9 The Outline of this Thesis

Chapter 2 is dedicated to a systematic literature review on the association between the dance technique of “turnout” and musculoskeletal injuries. Moreover, the review aimed to investigate the scientific background of forcing and compensating turnout, which has not yet been done in science.

The first study investigating the relationship between motivational climate created by the ballet teacher or ballet master and dancers’ musculoskeletal injuries is presented in Chapter 3.

Chapter 4 aims to document ballet dancers’ warm-up habits and a possible link between warm-up routines and physical injuries to dancers.

Chapter 5 clarifies dancers’ perceptions of causes for their acute and overuse injuries and investigates the support from ballet teachers and ballet masters dancers perceive for their injury prevention and wellbeing.

Chapter 6 is dedicated to a prospective longitudinal assessment of stress dancers perceived during and after injuries and thus, whether injury in itself can be regarded as stressor for dancers.

A general discussion of results and summary are being presented in Chapter 7, followed by a list of publications and acknowledgements.

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