Dance medicine: risk factors for dancers' musculoskeletal injuries

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Chapter 7

General Discussion

This thesis was dedicated to investigating aspects which advocate the synergy between dance medicine and dance pedagogy with the aim to prevent injuries in classical ballet dancers. As such we investigated crucial aspects in dance medicine and their association with 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. Three of our aims, chapters 3, 4 and 5, were investigated on the basis of an online survey study.

6.1 Chapter 2: Dance Technique & Turnout

Turnout is the most essential aspect of ballet technique, and the association between erroneous or biomechanically misaligned turnout and injuries is commonly claimed.[1] In Chapter 2, we studied this association by conducting a systematic literature review. Our review could not provide a scientific conclusion on the association due to the heterogeneity and low methodological quality of the available studies.

Turnout is the external rotation of the leg as a complex dance technical issue depending on the overall neuromuscular control of the individual dancer. Total turnout involves the whole body of a dancer with specific impact on the lumbar spine and its lumbosacral inclination.[2] The leg alignment is dominated by the dancer's active monitoring of the hip joint, as the strongest aspect of total turnout. However, natural and highly individual anatomical below-hip contributors also have significant influence on the dancer's total

turnout. Among them are the obligatory end rotation of the knee, the extend of the tibia torsion and the flexibility of the talocrural as well as Lisfranc and Chopart joint complexes.

Based on PRISMA Guidelines, our systematic literature search was supported by a librarian and involved seven databases (PubMed, Embase, Emcare, Web of Science, Cochrane Library, Academic Search Premier, ScienceDirect). Studies investigating the relationship between compensated or forced turnout and musculoskeletal injuries in all genders, all ages, and levels of expertise in dancers were included, provided that details on misaligned turnout measurements and injuries were stated. Of the 7 reviewed studies in chapter 2, all authors came to the conclusion that forced or compensated turnout was associated with injuries. However, neither “forced” nor “compensated turnout” has yet been uniformly defined, and several studies showed severe misinterpretation of the determinant. The studies investigating the lower extremities presented a hip-focus only while the non-hip contributors were reduced to being the compensation or forcing of turnout and thus responsible for injuries. As such, like some reviewed studies concluded, all dancers compensated turnout. Such misinterpretation of natural anatomical variations limit the understanding of injury mechanisms underlying misaligned turnout and prevent a scientific interpretation of the association between exposure and outcome.

Several papers have been published on turnout assessment or definition as well as related aspects of turnout.[3-5] The first publications date back to the 1980s/90s, and the relationship of erroneous turnout and injuries has ever since been claimed and investigated. [6, 7] However, our review could show that first and foremost a lack of standardized definitions and assessments of the determinant led to low methodological qualities of the reviewed publications and prohibit a scholarly conclusion on the relationship between misaligned turnout and injuries.

Although we were not able to draw a conclusion on the effect of erroneous or biomechanically misaligned turnout on injuries, several lessons can be learned from it. First, we found and could explain the described misconception of the turnout. Second, our review proposes the first medical clarification of "compensating" and "forcing" turnout based on the individuality of the dancer's body, which can prevent such misinterpretation and loss of resources in future studies. Third, we reason why total turnout of a dancer's leg including the motion of the lumbar spine is dependent on complex motion cycles rather than generalised (hip) joint dominance only. Fourth, we noted the importance of future study designs – and specifically recruitment methods of subjects – which rule out reverse causality. Hence reverse causality could have been an issue in almost all reviewed studies as dancers who were already injured were subjected to turnout measurements As such, forced or compensated turnout could have been the cause of their injuries or it could have been the other way round and their injuries had made them default to compensatory strategies in order to fulfil the demands of turnout. Fifth, our explanations offer methods of turnout assessment to facilitate as well as standardize future research. Preferably, such methods should be based on 3-D kinematic analysis in combination with physical examination, allowing for objective dual assessment of maximum passive joint range of motion to account for anatomical variations, locate sites prone to (overuse)injury, and investigate underlying injury mechanisms.

6.2 The Online Survey

In chapter 3, 4 and 5 we present three publications based on an online survey for which we contacted 188 ballet ensembles and 51 dance organizations. Adult ballet dancers were asked to participate. The first part of the survey used the Oslo Sports Trauma Center

Overuse Injuries Questionnaire[8] and additional items to assess overuse and acute injuries of the previous two years. In the second part, we used the Empowering and Disempowering Climate Questionnaire[9] to evaluate the motivational environment of the participants. The third part of our survey was dedicated to questions assessing aspects of science of training in dancers, such as warm-up. Another part asked dancers how they perceive their ballet teachers' and ballet masters' handling of different aspects related to their injury prevention.

The survey was executed anonymously, because pre-professional and professional dancers declared their fear of sanctions when they answered our questions about their teachers and masters. Such situations had been described in previous research[10] and were confirmed by our results presented in chapter 3 and 5. Since our survey study was based on self-report, recall bias might have occurred. Further limitations might be that we do not know whether our sample is representative for all dancers, although we included 29 nations. However, our design has shown to be important to encourage dancers to answer our questions in the first place. The wish of our sample to conduct the study anonymously has stressed the importance of our approach. By incorporating validated questionnaires for the majority of our survey we meant to ensure an appropriate level of scientific approach.

In total 192 ballet dancers answered more than 75% of the survey's items and were included in the studies. They had a mean age of 27 ±7.8 years and 83% were females. 203 acute injuries were reported by 119 dancers (62%) and 469 overuse injuries were documented in 164 dancers (85%).

6.3 Chapter 3: Motivational Climate & the Ballet Teacher / Master

In chapter 3 we investigated the association between motivational climate and musculoskeletal injuries. A motivational climate is the atmosphere which, amongst others, leaders, such as teachers, create for their learners or workers through their behavior. Two different climates are distinguished a (more) empowering or a (more) disempowering motivational climate. While the first supports autonomy, perceived competence, and relatedness and is associated with wellbeing, the latter thwarts those aspects and has been related to ill-being and reduced levels of performance.[11, 12] Sports science identified the motivational climate created by the coach in the etiology of athletes' injuries.[13, 14] In dance, and specifically in ballet, no studies have yet investigated such an association. Therefore, the association between an empowering (EMC) or disempowering (DMC) motivational-climate and musculoskeletal injuries in ballet was investigated.

The motivational climate was assessed with the Empowering-and-Disempowering-Motivational-Climate-Questionnaire[9] based on a 1-5-point Likert scale, while the Oslo-Sports-Trauma-Research-Centre-Overuse-Injury-Questionnaire[8] assessed overuse injuries within the last two years. Linear regression investigated the association between exposure and outcome, adjusting for the confounders age, sex, level of expertise (i.e., amateur, pre-professional or professional ballet dancer), years of experience, and the dancer's age at starting to dance ballet.

In general, no atmosphere or climate in the setting of ballet or dance, or any teacher/master is only good or only bad. Thus, in real-life as well as in the setting of ballet and dance, EMCs and DMCs co-exist[15, 16]. Therefore, we also studied the interaction

or effect moderation between the two sub-domains of motivational climate. We aimed to find out if EMC moderates the association between DMC and injuries and thus if EMC has a preventive effect on. For that reason, an interaction term between EMC and DMC assessed the effect modification based on the Johnston-Neyman-Score which identifies points in the range of the moderator (EMC) in which the interaction effect of X (DMC) on Y (injuries) becomes statistically significant.[15, 17]

The total mean score of EMC was 3.1 ±1.07, which was lower in pre-professional and professional dancers with a mean of 2.8 ±1.03. The DMC of the total population was 3.3 ±1.08. With 3.6 ±1.03 it was higher in pre-/professional dancers than in amateurs (2.7 ±0.89). Our results showed that EMC was associated with fewer acute (β=-0.22; 95%CI -0.40 to -0.04) and fewer overuse injuries (β=-0.74; 95%CI -0.99 to -0.50), while DMC was associated with more injuries (acute: β=0.30; 95%CI 0.13 to 0.47; overuse: β=0.74; 95%CI 0.50 to 0.98). When tested together and adjusted for confounders, EMC lost its protective effect while DMC was positively associated with injuries throughout all settings. Testing the interaction, EMC showed no moderating effects on DMC in the adjusted models of our regression analysis.

Our results contribute to future research and injury prevention in ballet environments. First, we could provide some initial indications that disempowering climates are related to musculoskeletal injuries in ballet dancers. Second, through the analysis of effect moderation we could show that the initially preventive effect of empowering climates disappeared with any nuances of disempowering climates being present. For dance practice these implications are of high significance. Since injury prevalence and risks in ballet are very high, it is paramount to find and install measures to prevent dancers' injuries. Our study was the first to show that the person of the ballet teacher (or ballet

master in professional environments) holds a key role regarding injury prevention in dancers. Before we conducted our study, the danger of disempowering, authoritative teacher/master behavior had been anecdotally claimed to be related to dancers' illbeing and their high injury risk. However, while literature documented and condemned narcistic, inappropriate teacher/master behavior[18, 19], no evidence existed to make this more than one of the many historical clichés told about classical ballet.

Many of the perceived and used values and norms ruling contemporary ballet environments date back to the first ballet academy founded by Louis XIV, the Acadèmie Royale de Danse in 1661.[20] Structures of ballet classes and training approaches have been following the same basic routines for decades and centuries.[21] However, demands imposed on dancers are constantly rising, the dancer has become a high performing athlete[22] rather than an artist only. Thus, some traditional notions of teaching and training dancers will have to adjust. One of them is the behavior of ballet teachers and masters. In our study population, this behavior relatively often created a disempowering climate, as DMC scores were high. Also, chapter 5 confirms the necessity of such a change towards empowering climates, if dancers' injuries want to be prevented, because dancers themselves have identified the person of the ballet teacher or ballet master as one of the most important perceived causes for their overuse injuries.

6.4 Chapter 4: Science of Training & Neuromuscular Warm-up

Neuromuscular warm-up programs (NMWU) have been shown to prevent injuries in sports science, investigating thousands of athletes from various fields, such as soccer or basketball.[23-27] In dance, research on warm-up is scarce, while the association between (neuromuscular) warm-up and injuries has not yet been studied at all.

Our aims in Chapter 4 were twofold: We used an online survey to ask ballet dancers from 18 years of age onwards to report their warm-up habits with the aim to provide documentation of warm-up routines among ballet dancers. Furthermore, we studied the association between neuromuscular warm-up and traditional ballet specific warm-up habits (TBSWU) and dancers' musculoskeletal injuries, respectively. Acute and overuse injuries sustained in the previous two years were recorded while warm-up behavior was assessed through 28 items specifically composed for the purpose of our study.

The documentation of the dancers' warm-up routines showed that 47.4% always warmed up with a mean duration of 20.7±13.2 minutes, while 9.4% of our population, including professionals, reported that they never warmed up. Furthermore, our results also verified ballet warm-up procedures which previously had only been anecdotally claimed: 63% based their warm-up on stretching, which has not shown to have injury-preventive effects on athletes[28, 29] but was, in the contrary, associated with injury in sports and dance science.[30-34] 58.9% of our dancers used dance technical-exercises and 53.6% used the barre. Both might add to injury risk through an increase of the already high numbers of repetitive movements in ballet, as also discussed in Chapter 5. However, 54.7% of ballet dancers already included strength-training into their warm-up routines, a component of injury-preventive neuromuscular warm-up.

For the analysis of a possible association between warm-up habits (neuromuscular versus traditional-stretching-based routines), dancers were grouped into NMWU or TBSWU groups based on the warm-up habits they reported. Previous analysis of neuromuscular warm-up programs used in sports science served as a model to identify the dancers for our NMWU group. Dancers qualifying for NMWU were warming up with exercises improving strength, power, proprioception, sensorimotor control, additionally providing

basic cardiovascular stimulus. The dancers identified for our TBSWU group used stretching, dance-technical exercises, marking steps or running-through-choreographies, and stretching with tools as their warm-up routines.

31 dancers (16.15%) classified for TBSWU, 16 dancers (8.3%) for NMWU. 145 dancers did combined exercises and were thus not included into either of the two groups. Separate linear regression analyses adjusted for confounding factors were performed for acute and overuse injuries. Our results confirmed previous investigations in sports science, showing that NMWU was associated with fewer overuse injuries compared to TBSWU (β = -2.34; CI95% -3.54 to -1.14). In our analysis, no association was found with acute injuries, which were less often observed than overuse injuries as the majority of dancers' injuries were overuse in nature. Bigger samples and prospective, randomized controlled studies are needed to test this association.

6.5 Chapter 5: Preventive Dance Medicine & Causes of Injuries

In Chapter 5 we asked dancers to report the causes they perceived for their injuries. Additionally, we asked them to rate the level of support they perceived from their ballet teachers and ballet masters through practical implementation of dance medical injury-preventive measures. We used an international cross-sectional online-survey with items based on the Fit-to-Dance-Questionnaire[35-37] and literature research assisted by a librarian. Adult amateur, pre-professional, and professional ballet dancers reported the perceived causes of their injuries which they sustained in the previous two years. Multiple answers per injury were possible, and reported causes were analyzed per-injury as well as per-dancer to meet the problem of interdependency and overestimation of causes: In the “per-injury” approach all causes of all injuries were included. In the “per-dancer”

approach we analyzed the different causes given by each dancer who sustained an injury. As such, each cause reported by an individual dancer was included only once, irrespective of whether a dancer reported the same cause multiple times in case of multiple injuries. The rating of the perceived level of support through implementation of preventive dance medicine by the dancers' ballet teachers and ballet masters was based on 21 items using a 5-point-Likert-scale.

Confirming results of previous studies, we also found that fatigue was the most frequently perceived cause for acute injuries (52.9%) in the per-injury and per-dancer analysis.[36] With 51.2%, pressure from the ballet teacher or ballet master was most frequently perceived as cause for overuse injuries in the per-injury analysis (specifically in pre-/professional dancers with 61.3%). In the per-dancer analysis, fatigue and overtraining scored highest for overuse injuries (n=107; 65.2%). Other causes dancers perceived as causes for their injuries were previous and repetitive injuries or erroneous dance technique, predominantly forcing of turnout. Perceived support of dancers' injury prevention from teachers and masters through practical implementation of dance medicine was perceived to be moderate to low, specifically in pre-professional and professional ballet dancers.

Our research not only provides another focus on the essential role of the ballet teacher and ballet master for injury prevention through practical inclusion of dance medicine into dancers' practice. It also allowed us to put the dancer into the spotlight by addressing them directly through our survey and putting the focus on their perception and opinion. Such an approach can be seen as an important contribution to future interventions in dance environments for three reasons. First, giving dancers a voice allows to gain deeper

insight into their world, their needs and how they perceive the development of their own injuries. This facilitates precise tailoring of future injury-preventive interventions. Second, asking dancers for their opinions and perceptions makes them feel listened to and heard. Hence, their active compliance for such interventions will be encouraged, because they feel empowered and actively involved.

Third, over centuries, the role of the dancer as a silent artist who is willing to suffer for their art form has manifested.[38, 39] This has resulted in paradox approaches in the attempt to accept and justify pain and injury as integrating aspect of ballet and dance [40, 41], numbing the natural instinct of a person to avoid and prevent them, or seek help with it. This necessity to develop such a ballet dancer's identity has shown to be different from the identities that link dancers of other dance styles, for instance hip hop.[42, 43] Such an identity is promoted by disempowering climates and leads to poor handling of pain and injury while it is detrimental to injury prevention, as we could show in Chapter 3. High tendencies towards eating- and body dysmorphic disorders, negative forms of perfectionism [44-46] as well as the detrimental notion that dancing comes with pain and injuries have become an integrating part of that identity[41], thwarting injury prevention in ballet. Our approach to directly address previously unresearched issues might contribute to change such shortcomings and support dancers' autonomy and self-determination in future.

6.6 Chapter 6: Injury as Stressor & Handling and Rehabilitation of Injury

Many prospective studies have shown the high prevalence and incidence of dancers' injuries.[47-50] Injuries and their sequelae might be regarded as a burden if they lead to increased psychological stress for those affected. While stress has shown to be one of the

risk factors for injury in dancers[51], however, no study has yet investigated this reverse association, i.e., whether injuries in dancers lead to heightened stress levels. Moreover, sports science has shown that athletes cope better with consecutive than with first-time-injury[52], another information which is missing in the field of dance medicine and science. For that matter, in Chapter 6 we investigated the stress levels dancers perceived for their first-time injury as well as their consecutive injuries and assessed whether first injuries have different stress levels than consecutive injuries.

145 Contemporary and Modern Dance Bachelor dance students were prospectively followed during five academic years (2016-2022). During the first month of each of the five cohort's academic year, respectively, dancers' baseline characteristics were recorded. The "Performing artist and Athlete Health Monitor" (PAHM)[10, 51, 53] served as the assessment tool. This monitoring system includes the VAS pain scale, the VAS stress scale, and the "Oslo Sport Trauma Research Center Questionnaire on Health Problems" (OSTRC)[8, 54]. Throughout the respective academic years, stress, injuries and injury severity were recorded monthly. The first-month assessment in September served as baseline assessment for stress level analysis in which dancers had to be injury free to be included in our study. Paired t-tests were conducted to compare dancers' baseline stress levels to their stress levels after first as well as consecutive injuries.

The OSTRC severity scores[8] served as reference for our definition of injuries. An "all-complaint injury" (i.e., substantial or non-substantial injury) was defined as "any physical complaint sustained by a dancer resulting in a severity score higher than zero (i.e., leading to consequences on participation, training volume, and/or performance), irrespective of the need for medical attention or time-loss from dance activities".[50] Substantial injuries

were health problems leading to moderate or severe reductions in training volume with a value of ≥13 on question 2 of the OSTRC Questionnaire or moderate, severe, or complete reductions in performance, reflected in a value of ≥13 on question 3 of the OSTRC Questionnaire.[8, 54] Non-substantial injuries were defined as problems requiring no or little reduction in training volume, shown as a recorded value lower than 13 on question 2 of the OSTRC Questionnaire or no or little reduction in performance, derived from a value lower than 13 on question 3 of the OSTRC Questionnaire.[8, 54] We categorized dancers as "dancers with substantial injuries" if they were injury-free in the month of baseline assessment (September) and sustained a substantial injury in the period between October and June. If they were injury-free in the month of baseline assessment (September) and sustained a non-substantial or substantial injury in the period between October and June, dancers were categorized as "dancers with all-complaint injuries". Perceived general stress scores were measured monthly, based on a visual analogue scale (VAS) ranging from 0 (no stress) to 100 (extreme amount of stress).

67 dancers, of which 58.2% were female, with a mean age of 18.8 ±.80 years sustained at least one injury. 33 of them reported at least one consecutive injury. For those "all-complaint injuries", OSTRC severity scores ranged from a mean of 28.7 ±17.5 for first to 31.4 ±17.1 for consecutive "all-complaint injuries". The mean baseline stress level for these "all-complaint injuries" was 24.3 ±17.2. All stress levels during first and consecutive "all-complaint injuries" were elevated compared to the baseline stress levels, 34.8 ± 18.7 and 35.1 ±23.0, respectively. There were no differences between stress levels during first and consecutive injuries for all-complaint as well as substantial injuries.

Our results could show that injuries in dancers are associated with increased stress levels and injury must therefore be regarded as a stressor in itself. However, while other athletes

have shown to cope better with consecutive injuries [52], dancers' stress levels were equally high after first injury and consecutive injuries, indicating that they do not. One reason might be that dancers learn early to regard injury as a sign for discipline and dedication[41, 55], attempting to turn injury and pain into a positive motivational factor as part of their unfortunate way of coping. However, many dancers are aware of the resulting internal controversy and vicious circle resulting from working through pain and injury while increasingly fearing their injuries' aggravation and thus their negative impact on their lives and performance abilities.[10, 41, 56] This aggravation we could show through our OSTRC severity scores which increased from first through consecutive injuries. The increasing stress levels we found could thus be due to dancers' increasing fear to become injured as well as dancers' anxiety upon sustaining an injury they commonly know they have to cope with by working through. Since injuries become more severe, stress levels thus will aggravate as well. Such increased stress levels [51] might facilitate consecutive or repetitive injuries which could contribute to the high number of overuse injuries and overtraining dancers have to face.

Our study is the first to highlight how much of a burden injury is for dancers, reflected in their increased stress levels from first-time through consecutive injury. With our analysis we want to highlight the importance of a self-responsible handling of pain and injury[56] in dance. Furthermore, we emphasize the importance of a holistic approach to injury rehabilitation.[57] Such an approach has to include a focus on dancers' psychological recovery as well as the generation of knowledge in dancers, teachers and administrating personnel regarding stress and injury management in order to avoid consecutive or repetitive harm. Such harm not only includes injuries derived from high stress levels[51]

but also possible ill-health through permanently increased psychological stress levels, e.g., decreased immune system, depression, or anxiety disorders.[58-60]

6.7 Conclusion & Outlook

In this thesis, several aspects of dance medicine and their association with dancers' musculoskeletal injuries were investigated. One of the aims was to provide preliminary evidence on topics which have not been investigated before. Another was to directly address shortcomings in dance environments, such as disempowering climates, low levels of support for injury prevention through superiors or the importance of correct handling of pain and injury as well as a holistic approach to injury rehabilitation. As such, our studies are meant to contribute to necessary changes within dancers' world which have to be introduced into dancers' environments with the aim to prevent the high numbers of musculoskeletal injuries in these dancers.

Although the person of teacher and master has remained unaddressed for so long, our investigations show how important the role of teaching and training personnel can be in the prevention of injuries. Our data give circumferential evidence that teachers / masters and trainers of dancers hold a key role in the prevention of dancers' injuries by early recognition of overuse and providing a healthy work environment. Even more, they have a major influence on and can co-create an empowering climate, which can prevent injuries of dancers. Since they spend many hours of training time with dancers, their role in the active implementation of research into practice is important, if done in an open discussion with dancers. Our research highlighted how dancers perceive the important association between their well- or ill-being and the role of their teachers/masters. As such we

confirmed previous research which has indirectly documented the deficiencies related to the role of the teacher. [19, 39-41, 55, 61]

Therefore, a focus on injury preventive measures, holistic injury rehabilitation, as well as the importance of follow-ups has to be stressed. As reasoned, first, is important that future research focuses on the person of the ballet teacher and ballet master, as a key person in injury prevention. Research should focus on the ballet teacher's and ballet master's awareness, attitudes, education and knowledge on musculoskeletal injuries and science of training as well as their motivational and educational skills. Second, future research should also actively include those it aims for, the dancers, to ensure their participation and facilitate any further cooperation, through which the dancers themselves can benefit from previously researched evidence. Dancers themselves are a key factor in their own injury prevention as well as rehabilitation. Their own knowledge of the correct handling of pain and injury is crucial in order to prevent an aggravation of their injuries as well as their stress levels. However, as our results from several studies showed, for dancers to be able to be self-responsible, it does not only need dancers' compliance, it also needs the environment provided by their superiors which empowers such responsibility. This already has to start in early education of dancers, as we could show in Chapter 6. In an open and close interaction between masters / teachers and dancers prevention of musculoskeletal injuries can be recognized early, and even better prevented in future by specific advices tailored to the individual dancer with his or her individual (anatomic / biomechanical) demands. Third, dancers as well as teaching and administrating personnel have to learn and apply evidence-based handling of pain and injury in order to prevent injuries as well as negative psychological stress in dancers' lives which has been attributed to (further)

injury[51] as well as mental illnesses such as depression and anxiety disorders and other effects on overall health.[58-60, 62, 63]

References Chapter 6

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