Dance medicine: risk factors for dancers' musculoskeletal injuries

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Chapter 5

Preventive Dance Medicine & Causes of Injuries

The perspective of ballet dancers on causes of dance injuries and implementation of preventive dance medicine by their ballet teachers and masters

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Submitted

Abstract

Ballet dancers have a high injury risk. We aimed to gain insight in the causes for acute and overuse injuries and the level of implementation of preventive dance medicine by ballet teachers/masters as perceived by dancers.

An international cross-sectional online-survey was based on the Fit-to-Dance-Questionnaire and literature. Adult amateur, pre-professional, and professional ballet dancers reported the perceived causes of their injuries sustained in the previous two years. Multiple answers per injury were possible. Additionally, the dancers rated the level of implementation of preventive dance medicine by their ballet teachers and ballet masters based on 21 items using a 5-point-Likert-scale. Causes were analyzed per-injury as well as per-dancer.

188 ballet ensembles and 51 dance organizations were contacted, 192 ballet dancers (mean age 27 ±7.8 years, 83% females) responded. 119 dancers (62%) reported 203 acute and 164 (85%) reported 469 overuse injuries. Fatigue was the most frequently perceived cause for acute injuries in the per-injury (43.8%) and per-dancer analysis (32.8%). For overuse injuries, pressure from the teacher/master was most frequently perceived as cause in the per-injury analysis (51.2%), specifically in pre-/professional dancers (61.3%). In the per-dancer analysis, fatigue/overtraining scored highest for overuse injuries (n=107; 55.7%). Other causes were previous/repetitive injuries (acute-per-injury: 26.1%, acute-per-dancer: 22.4%, overuse-per-injury: 46.3%, overuse-per-dancer: 53.1%) or erroneous dance technique (acute-per-injury: 24.6%, acute-per-dancer: 21.9%, overuse-per-injury: 47.8%, overuse-per-dancer: 45.3%). With regard to perceived level of implementation of dance medicine by ballet teachers/masters to

prevent musculoskeletal injuries, 2 items received high ratings, 12 moderate ratings and 6 low ratings.

Fatigue and pressure accounted for the majority of causes for injuries. Perceived support by ballet teachers/masters regarding injury prevention and dance medicine was moderate to low. Future research should focus on the awareness, attitudes and the important role of ballet teachers/masters for injury prevention in dancers.

5.1 Introduction

Ballet dancers have a high injury risk. In amateur ballet dancers an incidence rate of 0.97 injuries per 1.000 hours of dance exposure has been reported.(3) In professionals these numbers are higher, Allen et al reported an injury incidence rate of 4.4 injuries per 1000 hours of dance exposure with a mean of 6.8 injuries per dancer in one year(2). while the risk for pre-professionals to sustain an injury per year was 76%, with a yearly incidence of 1.42 injuries and a rate of injury of 1.38 per 1000 hours of dance.(1)

Risk factors for these musculoskeletal injuries have been investigated, however, the relationships between those risk factors and injuries are not clear yet.(4, 5) Injuries can place a high burden on the physical and psychological health of dancers. In addition they can have large financial consequences for the dancers themselves, their companies, and insurances.(1, 6, 7) Therefore, gaining insight in the causes of dance injuries in ballet is of utmost importance.

Literature has shown that there is a broad spectrum of risk factors and possible causes, which vary from suboptimal scheduling of training, leading to fatigue(8, 9), overtraining(10, 11), as well as injuries as a result of too little recovery time and adaptation of tissues after injuries (8, 12-15). Also factors such as repetitive movements, as well as erroneous dance technique which disrespects the individuality of the dancer(5) have been pointed out as causes of injuries. Knowledge on the prevention of eating disorders(16, 17) is as important as the differentiation between injury and pain as well as the handling of pain, injury, and repetitive injuries. Moreover, the likelihood a dancer would report and discuss injuries without fear of repercussions is low, specifically in disempowering motivational climates(18), while an optimal rehabilitation and transition back into normal

training are essential for full recovery. Even more these are vital aspects of injury prevention, while identification and elimination of risk factors for sustained injuries need to be handled accurately.(19-21)

Despite this growing body of research, injury rates and risks have not declined during the last decades(22) in pre-professional(1, 23), professional(2, 24) and amateur dancers.(25, 26) A few studies, for instance the Fit for Dance Surveys (27-29) have evaluated causes for injuries as perceived by dancers however the two injury mechanisms, acute and overuse, were not evaluated separately. Information on dancers' perceptions is essential to develop tailor-made injury prevention programs for the different types of ballet injuries. Therefore, the first aim of this study is to investigate the causes ballet dancers perceive for their acute and overuse injuries. Successful injury prevention could be supported by involving dancers directly. Giving dancers a voice will allow to base future measures of injury prevention on dancers' opinions, facilitating their essential compliance upon practical implementation, at best in collaboration with their teaching personnel.(30) The latter is supported by evidence from sports injury research showing that coaches are the most influential individuals for injury prevention in sports settings.(31, 32) They have the authority to promote prevention behaviors and are in charge of injury management.(33) Research has shown that the sports coach's attitude towards injury prevention programs is the major determinant of whether interventions reach their athletes.(34, 35) In ballet, the role of the ballet teacher or ballet master regarding injury prevention has not yet been investigated, although repeatedly addressed, discussed, and criticized.(29, 36-40) Therefore, the second aim is to gain insight how ballet dancers perceive and rate the implementation of preventive dance medical measures taken by their ballet teachers or ballet masters. As such, preventive dance medicine, derived from the construct

“preventive medicine“(41), includes all aspects of dance medicine which particularly aim for primary injury prevention. Since injury mechanisms as well as the need for preventive dance medical implementation has to be handled differently for amateur and pre- and professional settings, we reported our findings for both levels of expertise separately.

5.2 Methods

5.2.1 Study design

This study was part of a large scale international cross-sectional cohort study on ballet dance injuries.(18) The link to the online survey was presented via social media (Facebook, Instagram). A total of 188 ballet ensembles and 51 dance organizations from around the world were informed and asked to share the survey through their contacts and blogs. The survey was executed anonymously. The Medical-Ethic Committee Leiden | Den Haag | Delft approved the study as not falling under the rules of WMO, the Medical Research Involving Human Subjects Act (N19.082/RM/fIT1). Informed consent of the participants was obtained electronically.(18)

5.2.2 Participants

5.2.2.1 Inclusion & exclusion criteria

Eligible participants were adult (>18 years of age) professional, pre-professional, and amateur ballet dancers who had had a regular classical ballet training and experience for at least 3 years prior to participation. Excluded were dancers who answered less than 75% of the survey questions for this paper.

5.2.3 Assessments

5.2.3.1 Demographics

Sex, nationality, age when they started to dance ballet, years of ballet experience, and the workload of the previous two years were recorded based on self-report to assess baseline demographics. Weekly dancer exposure concerning participation in dance activity as well

as exposure time concerning activity duration were used to calculate weekly workloads. Dance exposure equals an event with unknown duration, e.g., participation in a class, rehearsal, or performance. Time exposure has a clear duration of 60 minutes per unit (hour). The level of expertise (i.e., pre-professional and professional, or amateur dancer) was derived from the reported time exposure hours based on previous research reporting work hours in dancers(42-45): Pre-professional and professional dancers were defined as dancers with 16+ time exposure hours per week, whereas amateurs had a maximum of 15 hours per week.

5.2.3.2 Injury

Acute injuries were defined as being related to an identifiable event and a precise onset(46) in the course of dance related activities such as performance, rehearsal, or technique class within the previous two years. Overuse injuries were defined as musculoskeletal complaints or injuries which could not be linked to a clearly identifiable event(46) but sustained within the previous two years(19) from dance related activities. Both injury types were recorded through 17 items, respectively. Sixteen pre-defined body parts were listed and one additional free-text item could be used to report other injuries than those associated with the predefined body parts. More details on injuries were published in a previous paper.(18)

5.2.3.3 Perceived causes for injuries

For each reported injury, dancers were asked to assess the causes they perceived. The Fit to Dance UK-Questionnaire(28, 47) served as an example for their assessment, allowing for multiple answers per injury. The list of 11 causes in the 1996-version and 16 causes in the 2005-version was extended for the purpose of this study, based on literature

research assisted by a librarian *(Appendix 2).* Titles and abstracts of the search results (n=224) were screened for keywords and eligible articles were read (n=120), resulting in 31 articles of the search included as references. Causes as well as risk factors investigated or discussed in at least one of the retrieved papers were added to the list of our survey, resulting in 34 predefined causes to be investigated, 17 for each injury type, respectively (*Appendix 1*). As in the Fit to Dance UK-questionnaires, an additional free-text option allowed to report any additionally perceived cause which was not in the list. Based on the literature research, our changes included: (1) a differentiation between reasons for acute and overuse injuries due to the different underlying mechanisms of injury etiology, and thus more listed possibilities for both types of injuries. (2) rewording of items to clarify meaning or allow for differentiation, e.g., '*repetitive movements in rehearsal*' became '*repetitive movement in rehearsal or training*'; '*insufficient warm up*' became '*insufficient warm up or cool/warm down*'; '*psychological (eg depression)*' was divided up into several aspects such as '*anxiety*', '*depression*', or '*insecurity (e.g., new or difficult choreography or technique that made you feel "unready")*'. (3) adding items such as '*Insufficient recovery time*', or '*Pressure from the ballet teacher or ballet master*'.

After the survey, two additional causes were added to our predefined list of causes based on the dancers' results: "Ballet teacher, ballet master (behavior, teaching/working methods)" was added as additional cause for acute injuries and "Forced turnout" was added to overuse injuries.

Causes were analyzed using two different approaches: per-injury and per-dancer. In the "per-injury" approach all causes of all injuries were included. Thus, all causes for each single injury were taken into account irrespective of the dancer who reported these

injuries. 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. We conducted these two different approaches to meet the problem of interdependency and overestimation of causes. For instance, a dancer with five overuse injuries who reported the cause ”repetitive or previous injury” for each of the five injuries, would in case of the per-injury analysis result in five times the cause “repetitive or previous injury”. In the per-dancer analysis, this would result in one time the cause “repetitive or previous injury”.

5.2.3.4 Implementation of preventive dance medicine into dance practice

Through 21 items, dancers were asked to rate their teachers’/masters’ efforts regarding the implementation of aspects of preventive dance medicine into practice. Recurrently, dancers were instructed to think about the previous two years and their primary ballet teacher or ballet master when answering. The phrasing and content of the questions were based on the „Empowering and Disempowering Motivational Climate Questionnaire” allowing to put a focus on the teacher/master.(48)

20 items addressed three selected umbrella aspects, which have received a lot of attention in dance science and have previously shown to be related to dancers' health and wellbeing: First, handling of pain and injury(20, 49) (e.g., dancing through pain, supporting reporting of pain, respecting medical orders) was asked in five items (e.g., *“My Ballet Master|Teacher|Pedagogue|Trainer tells me to work through pain because it is part of dancing.”*). Second, science of training(5, 8, 15, 45, 50, 51) (e.g., scheduling, rest-work-ratio and fatigue, warm-up, attitude towards and implementation of strength and

proprioceptive training, or acknowledgement of anatomical individuality) was documented using 10 items (e.g., *"My schedules include enough rest for me to feel fully recovered after training, rehearsal, performance."*). Third, sociopsychological support(18, 52), used five items (e.g., *"My Ballet Master|Teacher|Pedagogue|Trainer encourages dancers to speak out, e.g., addressing problems, wishes."*). One question with an additional free-text option served as opening question (i.e., *"My Ballet Master|Teacher|Pedagogue|Trainer talks about dance medicine"*).

All 21 items were based on a 1-5-Likert-scale (never=1 to always=5) with "sometimes" as median. In order to allow for an interpretation of results, cutoff points graded the Likert-mean-value into three equal categories, e.g., low level, moderate level and high level of implementation. That was accomplished by subtracting the lowest possible mean score from the highest (5-1=4) and dividing the results by three (5-1=4 : 3) resulting in even intervals of 1.33 for all three categories (1.00 + 1.33 = 2.33; 2.34 + 1.33 = 3.67; 3.68 + 1.33 = 5).(53) For supporting statements with regard to implementation of preventive dance medicine (e.g., *"My BMTPT wants me to report pain immediately…"*) the categories were 1.00-2.33 low, 2.34-3.66 moderate, and 3.67-5.00 for high level of preventive implementation. For non/supporting\ statements (e.g., *"My BMTPT tells me to dance through pain because it is part of dancing."*) the categories were reversed, resulting in 1.00-2.33 as high, 2.34-3.66 as moderate, and 3.67-5.00 as low.

5.2.4 Statistical analysis

Statistical analysis was based on SPSS 25 for Windows using descriptive statistics and explorative plots, normality was checked using histograms and QQ-Plots. Results were presented as mean values and percentages of the questions' Likert-scales. All analysis

were conducted for the whole study population and stratified for pre-/professional and amateur dancers.

Data on perceived causes for both types of injury (acute and overuse) were analyzed per injury, and per dancer in order to meet the issue of dependency. Cronbach's α was applied to test the internal reliability of the items investigating implementation of dance medicine, and explorative factor analysis (EFA) was used to identify the underlying structure of the scale (Extraction method: Maximum Likelihood; Rotation method: Equamax with Kaiser Normalization; Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett Test). This analysis tested the answers the dancers gave on a clear pattern and thus an internal reliability, e.g., whether the dancers understood the questions, whether negative statements were understood negatively and positive understood positively.

5.3. Results

5.3.1 Population

Of the 192 dancers who completed the questionnaire, 70% were pre-professional or professional dancers, 30% were amateurs, coming from 28 different nations.(50) The dancers had a mean age of 26.7 ±7.8 years, most dancers were female (82.8%). 119 dancers reported 203 acute injuries, with a range of one to six injuries per dancer. 164 dancers were affected by 469 overuse injuries, ranging from one to nine injuries per dancer *(Table 1).*

5.3.2 Perceived causes for injuries

For acute injuries, the mean number of causes per injury was 3.9 ±2.81. For overuse injuries the mean number of causes per injury was 10.8 ±9.84. For acute injuries, the most often reported cause was fatigue with 43.8% in the per-injury and 32.8% per-dancer analysis. With respect to overuse injuries, in the per-injury analysis pressure from the ballet teacher or ballet master was most frequently perceived as cause (n=240; 51.2%), predominantly in pre-professional and professional dancers (n=233; 61.3%). In the per-dancer analysis, “Fatigue, overtraining and overwork” was most the frequently perceived cause (n=107; 55.7%). Further causes were errors in the dance technique (acute-per-injury: 24.6%, acute-per-dancer: 21.9%, overuse-per-injury: 47.8%, overuse-per-dancer: 45.3%), or previous/repetitive injuries (acute-per-injury: 26.1%, acute-per-dancer: 22.4%, overuse-per-injury: 46.3%, overuse-per-dancer: 53.1%). Details can be found in *Table 2*.

5.3.3 Perceived implementation of dance medicine

Cronbach's α suggested good internal reliability between items which assessed the practical implementation of preventive dance medicine as supported or not supported (support α 0.909; no-support α 0.886). Explorative factor analysis (KMO 0.915; Bartlett Test p = 0.00) showed clear loading onto 2 factors, which was additionally verified in a Scree Plot.

Table 3 presents the results for how dancers perceive the support by their ballet teachers and masters with regard to the implementation of dance medicine into practice. The table is structured according to our categories, presented in the methods section: 1) handling of pain and injury, 2) science of training, and 3) sociopsychological support.

With regard to the perceived implementation of dance medicine, in pre-/professional dancers, 1 of the 21 items received high ratings, 9 aspects were reported to be moderately implemented and 11 received low support. In amateurs, 8 were highly incorporated, 7 moderately, and for 6 the implementation was low (*Table 3*).

Table 1: General demographics.
Values are given as the mean ±SD (range) or n(%) of the population
Time exposure (= per 60 minutes)
Dancer exposure (= per event, independent of the duration of the event, i.e., not necessarily 60 minutes)
Acute injuries were related to an identifiable event and a precise onset in the course of dance related activities such as performance, rehearsal, or technique class.
Overuse injuries were physical complaints or injuries which could not be linked to a clearly identifiable event but sustained from dance related activities such as performance, rehearsal, or technique class.

	All dancers	**Pre-/Professionals**	**Amateurs**
	192	132 (68.8)	56 (29.2)
Sex			
Female	159 (82.8)	102 (77.3)	53 (94.6)
Male	33 (17.2)	30 (22.7)	3 (5.4)
Age *(years)*	26.7 ±7.82 (41)	24.7 ±5.5 (25)	31.0 ±10.35 (41)
Ballet experience *(years)*	14.5 ±7.00 (49)	14.43 ±5.2 (30)	14.5 ±10.05 (49)
Age at ballet initiation *(years)*	8.1 ±5.84 (43)	7.37 ±3.02 (15)	9.8 ±9.46 (42)
Time exposure *(workload in hours/week)*	26.8 ±15.30 (59)	35.6 ±8.20 (44)	6.1 ±3.92 (14)
missings	4	4	0
Dancer exposure *(workload in events/week)*	12.3 ±9.60 (65)	16.1 ±9.28 (65)	4.25 ±2.80 (14)
missings	5	4	1
Acute injuries			
total number of acute injuries in the population	203 (in 119 dancers)	156 (in 87 dancers)	43 (in 29 dancers)
acute injuries per dancer	(6)	(6)	(3)
0	73 (38.0)	45 (34.1)	27 (48.2)
1	65 (33.9)	45 (34.1)	18 (21.1)
2	36 (18.8)	27 (20.5)	8 (14.3)
3 and more injuries	18 (9.6)	15 (11.36)	3 (5.4)
Overuse injuries			
total number of overuse injuries in the population	469 (in 164 dancers)	380 (in 117 dancers)	83 (in 44 dancers)
overuse injuries per dancer	(9)	(9)	(5)
0	28 (14.6)	15 (11.4)	12 (21.4)
1	42 (21.9)	20 (15.2)	20 (35.7)
2	33 (17.2)	20 (15.2)	13 (23.2)
3 and more injuries	89 (38.1)	77 (58.3)	11 (19.4)

Table 2: Causes dancers perceived for their acute and overuse injuries.
Causes are reported per injury n(%), and per dancer n(%) in which each reported cause was only included once for each dancer.

	ACUTE INJURIES					
	Reported causes per injury			Reported causes per dancer		
Reported causes	Acute injuries in all Dancers n=203	Acute injuries in Pre-/Professionals n=156	Acute injuries in Amateurs n=43	All dancers n=192	Pre-/Professionals n=132	Amateurs n=56
Fatigue (being exhausted; overly tired)	89 (43.8)	65 (41.7)	21 (48.8)	63 (32.8)	46 (34.8)	16 (28.6)
Previous or repetitive pain, complaint or injury	53 (26.1)	36 (23.1)	15 (34.9)	43 (22.4)	29 (22.0)	13 (23.2)
Technical errors in the dance technique	50 (24.6)	43 (27.6)	6 (14.0)	42 (21.9	35 (26.5)	6 (10.7)
Insufficient warm up or warm down	40 (19.7)	25 (16.0)	12 (28.0)	31 (16.1)	20 (15.2)	9 (16.1)
Floor	34 (16.7)	29 (18.6)	5 (11.6)	24 (12.5)	19 (14.4)	5 (8.9)
Insecurity (with a new choreography/technique making you feel “unready”)	30 (14.8)	25 (16.0)	5 (11.6)	22 (11.5)	18 (13.6)	4 (7.1)
Unfamiliar movements	29 (14.3)	22 (14.1)	6 (14.0)	22 (11.5)	16 (12.1)	5 (8.9)
Insufficient training status (e.g., strength, endurance, early specialization)	27 (13.3)	18 (11.5)	9 (20.9)	22 (11.5)	15 (11.4)	7 (12.5)
Ballet teacher, ballet master (behavior, teaching/working methods)	21 (10.3)	19 (12.2)	2 (4.7)	19 (9.9)	17 (12.9)	2 (3.6)
Partner, Pas de Deux, lifts	20 (9.9)	19 (12.2)	0 (0.0)	17 (8.9)	16 (12.1)	0 (0.0)
Insufficient preparation or preparation time (before performance etc.)	18 (8.9)	15 (9.6)	3 (7.0)	17 (8.9)	14 (10.6)	3 (5.4)
Poor diet, hunger and related fatigue, weakness or failure to concentrate	17 (8.4)	12 (7.7)	5 (11.6)	16 (8.3)	11 (8.3)	5 (8.9)
Different teachers, masters, chorographers and varying demands	16 (7.9)	12 (7.7)	4 (9.3)	14 (7.3)	10 (7.6)	4 (7.1)
Costumes, footwear	7 (3.4)	5 (3.2)	2 (4.7)	5 (2.6)	3 (2.3)	2 (3.6)
Props	5 (2.5)	5 (3.2)	0 (0.0)	4 (2.1)	4 (3.0)	0 (0.0)
Stage (curtains, sets, pictures, monuments, cables, or other)	5 (2.5)	4 (2.6)	1 (2.3)	5 (2.6)	4 (3.0)	1 (1.8)
Backstage	2 (1.0)	2 (1.3)	0 (0.0)	2 (1.0)	2 (1.5)	0 (0.0)
Lights, spotlights	1 (0.5)	1 (0.6)	0 (0.0)	1 (0.5)	1 (0.8)	0 (0.0)
Other reasons	13 (6.4)	9 (5.8)	4 (9.3)	13 (6.8)	9 (6.8)	4 (7.1)

Table 2 (continued): Causes dancers perceived for their acute and overuse injuries.
Causes are reported per injury n(%), and per dancer n(%) in which each reported cause was only included once for each dancer.

	OVERUSE INJURIES					
	Reported causes per injury			Reported causes per dancer		
Reported causes	Overuse injuries in all Dancers n=469	Overuse injuries in Pre-/Professionals n=380	Overuse injuries in Amateurs n=83	All dancers n=192	Pre-/Professionals n=132	Amateurs n=56
Pressure from the ballet teacher, ballet master	240 (51.2)	233 (61.3)	7 (8.4)	76 (39.6)	70 (53.0)	6 (10.7)
High repetition of the same movements	225 (48.0)	198 (52.1)	23 (27.7)	104 (54.2)	88 (66.7)	15 (26.8)
Technical errors in the dance technique	224 (47.8)	203 (53.4)	20 (24.1)	87 (45.3)	73 (55.3)	13 (23.2)
Fatigue, overtraining, overwork	222 (47.3)	176 (46.3)	41 (49.4)	107 (55.7)	80 (60.6)	25 (44.6)
Previous or repetitive pain, complaint or injury	217 (46.3)	188 (49.5)	28 (33.7)	102 (53.1)	81 (61.4)	20 (35.7)
Insufficient resting or recovery time	178 (38.0)	156 (41.1)	18 (21.7)	86 (44.8)	72 (54.5)	13 (23.2)
Insufficient warm up or warm down	83 (17.7)	57 (15.0)	25 (30.1)	48 (25.0)	29 (22.0)	18 (32.1)
Schedules (too tight, too demanding, unbalanced)	79 (16.8)	69 (18.2)	8 (9.6)	48 (25.0)	40 (30.3)	7 (12.5)
Floor	56 (11.9)	48 (12.6)	8 (9.6)	32 (16.7)	27 (20.5)	5 (8.9)
Insufficient training status (e.g., strength, endurance, early specialization)	53 (11.3)	35 (9.2)	17 (20.5)	34 (17.7)	22 (16.7)	11 (19.6)
Forcing turnout rotation (En Dehors)	49 (10.4)	46 (12.1)	3 (3.6)	29 (15.1)	27 (20.5)	2 (3.6)
Financial pressure, existential fear	46 (9.8)	44 (11.6)	2 (2.4)	27 (14.1)	26 (19.7)	1 (1.8)
Anxiety	40 (8.5)	35 (9.2)	5 (6.0)	27 (14.1)	22 (16.7)	5 (8.9)
Poor diet and related hunger, fatigue, or health consequences	38 (8.1)	27 (7.1)	11 (13.3)	28 (14.6)	19 (14.4)	9 (16.1)
Pressure from colleagues and peers	28 (6.0)	21 (5.5)	7 (8.4)	20 (10.4)	13 (9.8)	7 (12.5)
Different teachers, masters, choreographers and varying demands	21 (4.5)	18 (4.7)	3 (3.6)	16 (8.3)	13 (9.8)	3 (5.4)
Insufficient preparation or preparation time (before performance, etc.)	17 (3.6)	15 (4.0)	2 (2.4)	12 (6.3)	10 (7.8)	2 (3.6)
Depression	10 (2.1)	7 (1.8)	3 (3.6)	10 (5.2)	7 (5.3)	3 (5.4)
Partner, Pas de deux, lifts	6 (1.3)	6 (1.6)	0 (0.0)	5 (2.6)	5 (3.8)	0 (0.0)
Other reasons	26 (5.5)	21 (5.5)	5 (6.0)	23 (12.0)	18 (13.6)	5 (8.9)

Table 3: Questions to evaluate the perceived level of implementation of aspects of dance medicine and science into practice.
The values are displayed as Likert-1-5-point-scale mean values ±standard deviation in line with the respective question. Dancers' ratings are displayed an n(%)
BMTPT: Ballet Master, Ballet Teacher, Pedagogue, Trainer
Rating of the Likert-scale mean values in 1.33 intervals as a reference for the level of implementation:

Level of rating	High levels of implementation	*Moderate levels of implementation*	Low levels of implementation
Supporting statements	3.67-5.00	*2.34-3.66*	1.00-2.33
Non-supporting statements	1.00-2.33	*2.34-3.66*	3.67-5.00

Opening question	All dancers (n=192)	Pre-/Professional (n=132)	Amateur (n=56)
My BMTPT talks about dance medicine.	1.7 ±1.2	1.7 ±1.2	1.8 ±1.2
Never	130 (67.7)	93 (70.5)	36 (64.3)
Seldom	19 (9.9)	13 (9.8)	6 (10.7)
Sometimes	20 (19.4)	11 (8.3)	7 (12.5)
Very often	12 (6.3)	6 (4.5)	5 (8.9)
Always	11 (5.7)	9 (6.8)	2 (3.6)
Handling of pain and injury			
My BMTPT wants me to report pain immediately that he/she can adjust or cancel training etc.	*2.7 ±1.6*	*2.4 ±1.6*	*3.3 ±1.5*
Never	70 (36.5)	58 (42.9)	11 (19.6)
Seldom	29 (15.1)	21 (15.9)	8 (14.3)
Sometimes	24 (12.5)	13 (9.8)	11 (19.6)
Very often	27 (14.1)	18 (13.6)	8 (14.3)
Always	42 (21.9)	22 (16.7)	18 (32.1)
My BMTPT wants me to be checked by a medical professional with any complaint/pain/injury.	*3.0 ±1.5*	*2.9 ±1.5*	*3.4 ±1.4*
Never	40 (20.8)	31 (23.5)	9 (16.1)
Seldom	38 (19.8)	35 (26.5)	2 (3.6)
Sometimes	31 (16.1)	13 (9.8)	18 (3.1)
Very often	40 (20.8)	27 (20.5)	12 (21.4)
Always	43 (22.4)	26 (19.7)	15 (26.8)
My BMTPT tells me to work through pain because it is part of dancing.	*2.9 ±1.5*	*3.2 ±1.5*	2.1 ±1.2
Never	51 (26.6)	25 (18.9)	25 (44.6)
Seldom	33 (17.2)	23 (17.4)	9 (16.1)
Sometimes	35 (18.2)	21 (15.9)	13 (23.2)
Very often	34 (17.7)	25 (18.9)	8 (14.3)
Always	39 (20.3)	38 (28.8)	1 (1.8)
My BMTPT sticks to the medical professional's orders (e.g., rest, sick leave, modified training) that I can fully recover or heal injuries.	*3.2 ±1.5*	*2.8 ±1.5*	4.0 ±1.2
Never	39 (20.3)	36 (27.3)	3 (5.4)
Seldom	35 (18.2)	30 (22.7)	4 (7.1)
Sometimes	24 (12.5)	16 (12.1)	8 (14.3)
Very often	41 (21.4)	26 (19.7)	14 (25.0)
Always	53 (27.6)	24 (18.2)	27 (48.2)

Table 3 (continued): Questions to evaluate the perceived level of implementation of aspects of dance medicine and science into practice. The values are displayed as Likert-1-5-point-scale mean values ±standard deviation; n(%)

My BMTPT analyses my technique after I reported pain or injury to avoid further harm or repetitive injury.	*2.4 ±1.5*	**2.0 ±1.3**	*3.2 ±1.5*
Never	82 (42.7)	71 (53.8)	11 (19.6)
Seldom	33 (17.2)	23 (17.4)	9 (16.1)
Sometimes	23 (12.0)	12 (9.1)	10 (17.9)
Very often	26 (13.5)	16 (12.1)	10 (17.9)
Always	28 (14.6)	10 (7.6)	16 (28.6)
Science of training and acknowledgment of individuality			
My schedules include enough rest for me to feel fully recovered after training, rehearsal, performance.	*2.6 ±1.2*	**2.3 ±1.1**	*3.2 ±1.2*
Never	37 (19.3)	32 (24.2)	5 (8.9)
Seldom	60 (31.3)	46 (34.8)	13 (23.2)
Sometimes	44 (22.9)	35 (26.5)	9 (16.1)
Very often	40 (20.8)	15 (11.4)	23 (41.1)
Always	11 (5.7)	4 (3.0)	6 (10.7)
My schedules and training are adjusted to make sure that I am never overly fatigued.	**1.8 ±1.2**	**1.5 ±1.0**	*2.4 ±1.4*
Never	113 (58.9)	90 (68.2)	21 (37.5)
Seldom	38 (19.8)	27 (20.5)	11 (19.6)
Sometimes	20 (10.4)	7 (5.3)	12 (21.4)
Very often	11 (5.7)	4 (3.0)	6 (10.7)
Always	10 (5.2)	4 (3.0)	6 (10.7)
My BMTPT shortens/cancels breaks to make me train/rehearse longer.	*2.6 ±1.4*	*3.0 ±1.3*	1.8 ±1.1
Never	62 (32.3)	26 (19.7)	33 (58.9)
Seldom	33 (17.2)	21 (15.9)	11 (19.6)
Sometimes	36 (18.8)	30 (22.7)	6 (10.7)
Very often	43 (22.4)	38 (28.8)	5 (8.9)
Always	18 (9.4)	17 (12.9)	1 (1.8)
My BMTPT insists that I warm up.	**1.8 ±1.3**	**1.6 ±1.3**	**2.1 ±1.4**
Never	133 (69.3)	101 (76.5)	31 (55.4)
Seldom	17 (8.9)	9 (6.8)	6 (10.7)
Sometimes	13 (6.8)	3 (2.3)	10 (17.9)
Very often	11 (5.7)	8 (6.1)	3 (5.4)
Always	18 (9.4)	11 (8.3)	6 (10.7)
My BMTPT tells me that strength training is bad for my aesthetic line.	1.9 ±1.3	2.2 ±1.4	1.3 ±0.8
Never	122 (63.5)	71 (53.8)	47 (83.9)
Seldom	12 (6.3)	9 (6.8)	3 (5.4)
Sometimes	26 (13.5)	23 (17.4)	3 (5.4)
Very often	19 (9.9)	16 (12.1)	3 (5.4)
Always	13 (6.8)	13 (9.8)	0 (0.0)

Table 3 (continued): Questions to evaluate the perceived level of implementation of aspects of dance medicine and science into practice. The values are displayed as Likert-1-5-point-scale mean values ±standard deviation; n(%)

My BMTPT wants me to close eyes in balances or shorter combinations.	**1.6 ±1.0**	**1.4 ±1.0**	**1.8 ±1.0**
Never	135 (70.3)	106 (80.3)	28 (50.0)
Seldom	25 (13.0)	10 (7.6)	13 (23.2)
Sometimes	19 (9.9)	6 (4.5)	12 (21.4)
Very often	9 (4.7)	6 (4.5)	3 (5.4)
Always	4 (2.1)	4 (3.0)	0 (0.0)
My BMTPT wants me to train without mirrors.	*2.6 ±1.0*	*2.6 ±1.0*	*2.7 ±1.0*
Never	28 (14.6)	20 (15.2)	7 (12.5)
Seldom	58 (30.2)	39 (29.5)	17 (30.4)
Sometimes	77 (40.1)	55 (41.7)	21 (37.5)
Very often	23 (12.0)	13 (98)	10 (17.9)
Always	6 (3.1)	5 (3.8)	1 (1.8)
My BMTPT wants me to train without barre.	**1.8 ±1.1**	**1.7 ±1.0**	**2.2 ±1.1**
Never	104 (54.2)	79 (59.8)	21 (37.5)
Seldom	44 (22.9)	30 (22.7)	14 (25.0)
Sometimes	27 (14.1)	13 (9.8)	14 (25.0)
Very often	11 (5.7)	6 (4.5)	5 (8.9)
Always	6 (3.1)	4 (3.0)	2 (3.6)
My BMTPT wants me to turn the feet out further than I think I can.	*2.9 ±1.6*	*3.3 ±1.6*	2.0 ±1.3
Never	64 (33.3)	33 (25.0)	28 (50.0)
Seldom	25 (13.0)	13 (9.8)	11 (19.6)
Sometimes	19 (9.9)	13 (9.8)	6 (10.7)
Very often	40 (20.8)	32 (24.2)	8 (14.3)
Always	44 (22.9)	41 (31.1)	3 (5.4)
My BMTPT prevents me from turning out too much that I can maintain my correct leg axis.	*2.5 ±1.6*	**2.0 ±1.4**	*3.5 ±1.5*
Never	88 (45.8)	76 (57.6)	11 (19.6)
Seldom	20 (10.4)	15 (11.4)	4 (7.1)
Sometimes	25 (13.0)	17 (12.9)	8 (14.3)
Very often	24 (12.5)	10 (7.6)	14 (25.0)
Always	35 (18.2)	14 (10.6)	19 (33.9)
Psychological support			
My BMTPT encouraged dancers to speak out (e.g., addressing problems, wishes).	**1.0 ±1.07**	**0.8±1.02**	**1.27±1.05**
Never	89 (46.4)	70 (53.0)	19 (33.9)
Seldom	41 (21.4)	31 (23.5)	9 (16.1)
Sometimes	44 (22.9)	21 (15.9)	22 (39.3)
Very often	15 (7.8)	8 (6.1)	6 (10.7)
Always	3 (1.6)	2 (1.5)	0 (0.0)
My BMTPT did not appreciate questions or opinions.	2.1 ±1.36	*2.5±1.28*	1.1±1.0
Never	32 (16.7)	12 (9.1)	19 (33.9)
Seldom	38 (19.8)	18 (13.6)	18 (32.1)
Sometimes	43 (22.4)	28 (21.2)	15 (26.8)
Very often	42 (21.9)	38 (28.8)	3 (5.4)
Always	37 (19.3)	36 (27.3	1 (1.8)

Table 3 (continued): Questions to evaluate the perceived level of implementation of aspects of dance medicine and science into practice. The values are displayed as Likert-1-5-point-scale mean values ±standard deviation; n(%)

My BMTPT commented on my weight.	*2.4 ±1.5*	*2.7 ±1.6*	1.7 ±1.0
Never	89 (46.4)	52 (39.4)	34 (60.7)
Seldom	26 (13.5)	13 (9.8)	12 (21.4)
Sometimes	23 (12.0)	17 (12.9)	6 (10.7)
Very often	24 (12.5)	22 (16.7)	2 (3.6)
Always	30 (15.6)	28 (21.2)	2 (3.6)
My BMTPT made sure that things to do were within my range of capabilities that I can feel secure and self-confident.	*2.8 ±1.3*	**2.3 ±1.3**	3.8 ±0.9
Never	49 (25.5)	48 (36.4)	0 (0.0)
Seldom	31 (16.1)	28 (21.2)	3 (5.4)
Sometimes	51 (26.6)	31 (23.5)	18 (32.1)
Very often	39 (20.3)	16 (12.1)	22 (39.3)
Always	22 (11.5)	9 (6.8)	13 (23.2)
My BMTPT encouraged me to think about the end of my dancing career and make plans for the future or consult a career transition specialist.	**1.6 ±1.1**	**1.6 ±1.1**	**1.6 ±1.1**
Never	139 (72.4)	95 (72.0)	40 (71.4)
Seldom	22 (11.5)	17 (12.9)	5 (8.9)
Sometimes	15 (7.8)	8 (6.1)	7 (12.5)
Very often	7 (3.6)	5 (3.8)	2 (3.6)
Always	9 (4.7)	7 (5.3)	2 (3.6)

5.4 Discussion

First, this study aimed to investigate the causes ballet dancers perceived regarding their sustained acute and overuse injuries in the previous two years. Secondly, dancers were asked to rate their perceived teachers'/masters' level of implementation of three selected aspects of preventive dance medicine (science of training, handling of pain and injury, psychological support). When taking all individual injuries and their individual causes into account we found that fatigue was the most frequently perceived cause for acute injuries. For overuse injuries, pressure by teachers and masters was the cause most often reported, predominantly in pre-professional and professional dancers. When looking at the causes reported per dancer, we found that fatigue, overtraining and overwork also scored highest for overuse injuries, followed by high repetitions of the same movements and previous/repetitive injury. The causes dancers perceived of their injuries were mirrored in the level of support they perceived regarding implementation of preventive dance medicine. In pre-/professional settings, practical implementation of preventive dance medicine received low to moderate support by ballet teachers and masters. In amateur dancers, support was perceived as moderate to high.

5.4.1 Overuse injuries as complex multifactorial issue

Our analyses of perceived causes were conducted separately, "per-injury" and "per-dancer", to meet the issue of interdependency of causes for multiple injuries in single dancers. Additionally, we investigated causes for acute and overuse injuries separately. As our findings show, for acute injuries little differences were present between "per injury" or "per dancer", showing that dancers contributed equally to the perceived causes. Moreover, for acute injuries, the mean number of causes dancers reported per injury was

3.9. Although causes of acute injuries, as we showed, are often multifactorial, the causes are most often known, facilitating diagnosis but also treatment as well as documentation for later evaluation.(46) With an average of 10.8 causes per injury, however, dancers reported more causes for each of their overuse injuries than for the acute injuries, indicating they could not as clearly decide for a cause as with acute injuries. This supports the issue of complexity of overuse injuries which might be more difficult to handle. They develop over a longer period of time, consequently multiple factors will contribute to their development. For that matter, our dancers reported several causes stressing the complex multifactorial nature of overuse injuries compared to acute injuries. Our findings support previous publications on the difficulty of defining, recording, handling as well as preventing overuse injuries(54) and highlight their multifactorial causality.(55) The interaction and interdependency of causes has to be taken into account in order to prevent underreporting or simplification of the complex issue of overuse injuries. Future research might benefit from such an approach in order to investigate the complexity of overuse injuries.

5.4.2 Perceived causes and implementation of preventive dance medicine

In line with our findings, fatigue, exhaustion and overwork have already been reported as causes for injuries in dancers.(28, 56). Previous research investigating the demands of ballet dancers' work days(45) showed that 90% of the ballet professionals spent less than 60 consecutive minutes resting at any one time during their work day, 33.3% even less than 20 minutes. Moreover, overtraining due to imbalances in work-to-rest ratio (16, 56) has also been associated with a decline in performance, long-term health issues, injuries (especially overuse) and burnout.(10, 57) As such, time exposure and related fatigue from

duration and intensity of workload can be linked to injury risk. Possible training asymmetries which disrespect the necessary balance between load and loadability of injured or overused tissue can further prolong fatigue through abnormal training responses. That again could prolong recovery time while increasing (re-)injury risk and declining performance outcomes. In our population, fatigue was perceived as cause for 44% of all acute and 56% of all overuse injuries, while only 26% of the dancers reported that their schedules included enough rest to feel fully recovered.

The importance of correct handling of pain and injury, the recognition of a dancer's individuality as well as the installation of an empowering motivational climate are stressed to reduce the risk of (repetitive) injuries.(5, 18, 58) As researched in sports science, the coach is the first and foremost institution when it comes to injury prevention in athletes(31, 32, 34, 35), which can also be confirmed by our results in ballet dancers. In our population, the top five causes for overuse injuries in both analyses are, at least partially a direct responsibility of the teacher or master.(29) Those causes, such as planning of training, dance technique, or fatigue and overtraining, scored high as perceived causes while support of teacher/master for those aspects was perceived as moderate to low.

Ballet teachers and ballet masters' hold an important and influential role as significant others in direct contact with the dancer. How they talk to and treat dancers can directly contributes to the etiology of dancers' injuries.(18) In our population, nearly 50% of the dancers documented that teachers or masters never commented on their weight. Although with 50% moderate, this might be a first step towards the prevention of eating disorders, since a high focus on low weight can contribute to injuries.(37) However, in other respects, our population documented teacher/master behavior of dangerously low levels of support. With a mean of 0.8 of 5 available points on the Likert-scale in pre-

/professionals, perceived support to speak out in case of problems or wishes received the lowest rating of all available items. Distress in dancers increases if the climate of reporting an injury, speaking out on shortcomings, or becoming injured altogether is answered with sanctions or disempowering teacher behavior.(30, 59) Even more, such distress was found to be associated with a prolonged recovery time as well as increased (re-)injury risk.(60, 61) For that matter, negative engagement between teacher and dancer does not support the implementation of injury-preventive dance medical approaches for which empowering motivational climates are as essential as early identification and correct handling of pain and injury.(18, 20)

While often regarded as historical cliché(40), such aspects of controlling behavior by authorities(18, 38) must not be underestimated.(62) Our analysis showed that those dancers who perceived pressure from their teachers/masters and who reported teacher/master related aspects as causes for their injuries also reported the highest number of injuries. As stated in the methods section, dancers used the “other causes” option for acute injuries so often to report behavioral extremes in their ballet teachers/masters that we included those as additional cause into our analysis. The teacher/master is by far not the only factor contributing to the etiology of dance injuries. However, as described in sports science(34, 35), they are in a key position(18, 29, 52) with regard to injury prevention. The latter is supported by our results. While teachers and masters themselves are under pressure to „produce perfect dancers”, however, in times of available scientific approaches to education and performance enhancement, they would also have evidence-based support to fulfill their key role in dancers injury prevention efficiently.(39, 63)

Based on our analysis, different injury preventive measures should be developed and implemented for dancers' acute and overuse injuries. Dance medical interventions focusing on fitness and conditioning have shown injury-preventive results by first and foremost acknowledging the needs and individuality of dancers in practice.(12) Our results indicate that more aspects might need a focus on the dancer's individuality. For instance individual perceptions of fatigue, insufficient preparation time before a premiere and necessary adaptation of schedules, a focus on the individual's abilities and anatomy with respect to dance technique, screening after injury to avoid further harm, the need to match individual skill levels with choreographic demands, or individual corrections of insufficient training status should be taken into account. Those were further aspects perceived as causes for injuries in our population while simultaneously reported to receive little support from ballet teachers/master with respect to implementation of preventive dance medicine.

Erroneous dance technique has already been described as risk factor(64, 65) perceived in 25% of acute and 48% of overuse injuries in our population. Furthermore, 49 dancers (per-injury: 10.4%, per-dancer: 15.1%) specified forcing turnout as the most frequently perceived dance technical error leading to their injuries in the "other causes"-item, making us include it as an individual cause. While the association between erroneous turnout and injuries needs further scientific clarification(5), our results show that in practice dancers t perceive the neglect of their individuality in the historical striving for „ideal turnout" of 180° as a cause for injuries.

Targeted integration of conditioning (e.g., strength and proprioception training) as well as appropriate warm-up are to be considered essential aspects of evidence-based teaching, training and injury prevention.(12, 50) The answers of our study population indicate that

two thirds of teaching personnel do not regard strength training as a threat to the dancer's aesthetics(66), while a lack of conditioning was only perceived as cause for 9% of all acute and 11% of all reported overuse injuries. This is an essential step towards the acknowledgment of athleticism in dance and away from related historical approaches. However, only a small number of teachers focus on warm-up(50) and exercises for proprioception training(67, 68) as well as related aspects such as the targeted use of mirrors(37, 69, 70) or barres.(71, 72)

A further aspect also highly depends on proactive inclusion of preventive dance medicine and does not appear to receive sufficient implementation. Psychological and social support with regard to transitioning from active career into second career path or retirement has been discussed in previous research.(73) A focus on positive, conscious and professionally guided preparation for that transition in order to reduce stress, prevent denial and fight risk of psychological and physiological ill-health has been recommended.(73) Our population reported very low levels of support, which, however, should already be part of vocational education.

The differences between pre-/professional and amateur dancers show that injury preventive approaches need to be different in various levels of expertise. While injury preventive dance medicine seems to be better supported in amateur settings on the first impression, results should not be used for comparison. Lives, work load, pressure, as well as goals are different between professional and leisure-oriented dance environments. Therefore, we recommend to develop preventive strategies at a more personalized, individual basis and not a one-size-fits-all approach. Amateur dance settings are supposed to have a focus on enjoyment and thus will differ with respect to injury-related outcomes. However, literature has shown that amateurs have to cope with unreasonable

levels of pain and numbers of injuries as well(3, 43), confirmed by our results. The fact that amateurs reported fatigue as the highest perceived cause for both types of injuries might also show the need to monitor aspects such as planning of training in amateur settings. Teachers might be trying to compensate for lower training frequency by increasing training intensity. Any resulting overload could be a reason for the answers of our amateur-population although our number of amateurs was too low to discuss conclusions.

5.4.3 Strengths and limitations

Some limitations of our study have to be acknowledged. First, as with all surveys based on self-report, recall bias will be present for all reported data. Moreover, we don't know whether dancers recalled all of their injuries because minor ones might be easier forgotten than severe or recurring ones which might have been counted less when they occurred several times. Secondly, for our population our results are not presented in the context of workload/1000-hours of dance as we did not assess hours of dance per week over time. Thirdly, we also do not know whether our population is representable for the dancers' population, although we were able to include a very representable number of different nationalities and thus backgrounds. However, our study is the first study using a dual analysis of perceived causes, the per-dancer and per-injury analysis, providing essential insight into acute and overuse injuries which were additionally assessed separately. Moreover, it is a first approach through two different perspectives, namely the perceived causes and the perceived support for injury prevention with a clear focus on the ballet teacher/master. Therefore, we believe that our results may contribute to dance injury prevention. The anonymous design which was not restricted to one school or company

was deliberately chosen to support dancers to speak out and comply, which has been a previous and recurrent issue.(18, 30)

5.5 Conclusion

Fatigue and pressure accounted for the majority of causes for injuries. Perceived support by ballet teachers/masters regarding injury prevention and dance medicine was moderate to low. Our results could show that the individuality of dancers should be regarded as an important aspect in injury prevention. By documenting dancers' perceptions as well as the support for the implementation of dance medical research into dance practice dancers receive, we could stress the importance of implementing dance medical research into practice. Such support, among other measures, might be essential to reduce injuries in ballet dancers. Our results also contributed by highlighting the important role of the teacher/master as a major factor in practical implementation of dance medicine. Future research should also analyze, which causes teachers/masters perceive for their dancers' acute and overuse injuries and evaluate teachers'/masters' scientific knowledge and their awareness of the importance of their role in injury prevention through the practical implementation of dance medical research into dance practice. High levels of education in teachers and masters are of utmost importance, because many perceived causes and low levels of practical implementation are related to them and their scientific/practical expertise.

Appendix 1: Multiple response questions to evaluate the reasons, which dancers perceive for their acute or overuse injuries accompanying the injury assessment of each body part.

Acute injuries were related to an identifiable event and a precise onset in the course of dance related activities such as performance, rehearsal, or technique class.

Overuse injuries were physical complaints or injuries which could not be linked to a clearly identifiable event but sustained from dance related activities such as performance, rehearsal, or technique class.

What do you think was the cause of this acute injury?

1) Fatigue (i.e., being exhausted, overly tired)
2) Floor
3) Insufficient warm up or warm down
4) Insecurity (e.g., with a new or difficult choreography or technique making you feel "unready")
5) Different teachers, masters, chorographers, repertory, or varying demands
6) Unfamiliar movements
7) Poor or inadequate diet, hunger, and related fatigue, weakness, or failure to concentrate
8) Partner, partnering work, lifts
9) Props
10) Environment, stage (temperature, curtains, sets, pictures, monuments, cables, etc.)
11) Backstage (stairs, steps, cables, or other)
12) Lights, spotlights
13) Costumes, footwear
14) Previous or repetitive pain, complaint or injury, ignoring early warning signs
15) Technical errors in the dance technique
16) Insufficient training status (e.g., strength, endurance, early specialization)
17) Insufficient preparation or preparation time (before performance etc.)
18) Other: …….. *(open text question)*

What do you think was the cause of this overuse injury/complaint?

1) Fatigue, overtraining, overwork
2) Floor
3) Insufficient warm up or warm down
4) Different teachers, masters, choreographers and varying demands
5) High repetition of the same movements
6) Poor or inadequate diet and related hunger, fatigue or health consequences
7) Pressure from the ballet teacher, ballet master
8) Pressure from colleagues and peers
9) Previous or repetitive pain, complaint or injury, ignoring early warning signs
10) Technical errors in the dance technique
11) Schedules (e.g., too tight, too demanding, unbalanced)
12) Anxiety
13) Depression
14) Financial pressure, existential fear
15) Insufficient resting or recovery time
16) Insufficient training status (e.g., strength, endurance, early specialization)
17) Insufficient preparation or preparation time (before performance, etc.
18) Other: …….. *(open text question)*

Appendix 2: Search strategy

(("Dancing"[mesh] OR "dancer"[tw] OR "dancers"[tw] OR "dancing"[tw] OR "dance"[tw] OR "dances"[tw] OR "danc*"[tw] OR "classical ballet"[tw] OR "ballet"[tw] OR "ballet*"[tw] OR "ballerina"[tw] OR "ballerina*"[tw] OR "aesthetic sports"[tw] OR "aesthetic sport"[tw] OR "esthetic sports"[tw] OR "aesthetic sports"[tw]) AND ("overuse injury"[tw] OR "overuse injuries"[tw] OR "overuse injur*"[tw] OR "over use injury"[tw] OR "over use injuries"[tw] OR "over use injur*"[tw] OR "overuse trauma"[tw] OR "overuse trauma*"[tw] OR "overuse foot injuries"[tw] OR "overuse ankle injuries"[tw] OR "overuse foot injur*"[tw] OR "overuse ankle injur*"[tw] OR "overuse knee injur*"[tw] OR "overuse knee injur*"[tw] OR "overuse lower extremity injuries"[tw] OR "overuse lower extremity injur*"[tw] OR "overuse lower limb injuries"[tw] OR "overuse lower limb injur*"[tw] OR "overuse musculoskeletal injuries"[tw] OR "overuse musculoskeletal injur*"[tw] OR "overuse related injuries"[tw] OR "overuse tendon injuries"[tw] OR "overuse tendon injur*"[tw] OR "overuse type injuries"[tw] OR "overuse type injur*"[tw] OR (("overuse"[tw] OR "over use"[tw] OR "overus*"[tw] OR "over us*"[tw]) AND ("Wounds and Injuries"[Mesh] OR "injury"[tw] OR "injuries"[tw] OR "injured"[tw] OR "injur*"[tw] OR "injuries"[Subheading] OR "fracture"[tw] OR "fractures"[tw] OR "fractured"[tw] OR "fractur*"[tw] OR "trauma"[tw] OR "trauma*"[tw] OR "nontraum*"[tw] OR "rupture"[tw] OR "ruptured"[tw] OR "ruptur*"[tw] OR "tear"[tw] OR "tear*"[tw])) OR "acute injury"[tw] OR "acute injuries"[tw] OR "acute injur*"[tw] OR "acute trauma"[tw] OR "acute trauma*"[tw] OR "acute foot injuries"[tw] OR "acute ankle injuries"[tw] OR "acute foot injur*"[tw] OR "acute ankle injur*"[tw] OR "acute knee injur*"[tw] OR "acute knee injur*"[tw] OR "acute lower extremity injuries"[tw] OR "acute lower extremity injur*"[tw] OR "acute lower limb injuries"[tw] OR "acute lower limb injur*"[tw] OR "acute musculoskeletal injuries"[tw] OR "acute musculoskeletal injur*"[tw] OR "acute related injuries"[tw] OR "acute tendon injuries"[tw] OR "acute tendon injur*"[tw] OR "acute type injuries"[tw] OR "acute type injur*"[tw] OR (("Acute Disease"[mesh] OR "acute"[tw] OR "sudden"[tw] OR "sudden*"[tw]) AND ("Wounds and Injuries"[Mesh] OR "injury"[tw] OR "injuries"[tw] OR "injured"[tw] OR "injur*"[tw] OR "injuries"[Subheading] OR "fracture"[tw] OR "fractures"[tw] OR "fractured"[tw] OR "fractur*"[tw] OR "trauma"[tw] OR "trauma*"[tw] OR "nontraum*"[tw] OR "rupture"[tw] OR "ruptured"[tw] OR "ruptur*"[tw] OR "tear"[tw] OR "tear*"[tw]))) AND ("faulty technique"[tw] OR "faulty techniques"[tw] OR "Faulty dance technique"[tw] OR "Faulty dance techniques"[tw] OR "technique"[ti] OR "techniques"[ti] OR "technical flaws"[tw] OR "technical flaw"[tw] OR "alignment"[tw] OR "repetition of same movements"[tw] OR "repetition of same movements"[tw] OR "repetition of movements"[tw] OR "repetition of movements"[tw] OR "repetition"[tw] OR "repetitive"[tw] OR "dancefloor"[tw] 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