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Dance medicine: risk factors for dancers' musculoskeletal injuries

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Appendices

Summary

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In Chapter 2, a systematic review aimed to investigate if compensating or forcing turnout (TO) leads to musculoskeletal injuries. Injury prevalence in dancers is high, and misaligned TO is claimed to bear injury risk.

The systematic literature review was conducted according to the PRISMA Guidelines using the databases of PubMed, Embase, Emcare, Web of Science, Cochrane Library, Academic Search Premier, and ScienceDirect. Studies investigating the relationship between compensated or forced TO and injuries in both genders, all ages, and levels of dancers were included. Details on misaligned TO measurements and injuries had to be provided. Screening was performed by two researchers, data extraction and methodological quality assessment executed by one researcher and checked by another.

7 studies with 1293 dancers were included. Methodological quality was low due to study designs and a general lack of standardised definition of pathology and methods of assessment of misaligned TO. The studies investigating the lower extremities showed a hip-focus only. Non-hip contributors as well as their natural anatomical variations were not accounted for, limiting the understanding of injury mechanisms underlying misaligned TO. As such no definite conclusions on the effect of compensating or forcing TO on musculoskeletal injuries could be made.

Total TO is dependent on complex motion cycles rather than generalised (hip) joint dominance only. Objective dual assessment of maximum passive joint range of motion through 3D kinematic analysis in combination with physical examination is needed to account for anatomical variations, locate sites prone to (overuse)injury, and investigate underlying injury mechanisms.

Sports science identified the trainer-athlete-relationship in the etiology of injuries. In Chapter 3, we aimed to investigate 1. the association between empowering (EMC) and disempowering (DMC) motivational-climate (MC) and musculoskeletal injuries in ballet, 2. if EMC moderates the association between DMC and injuries.

A cross-sectional cohort survey-study was conducted among ballet dancers (>18 years) reporting acute and overuse injuries of the previous two years. MC was assessed with the Empowering-and-Disempowering-Motivational-Climate-Questionnaire (1-5-Likert). The Oslo-Sports-Trauma-Research-Centre-Overuse-Injury-Questionnaire assessed severity of overuse injuries. Linear regression was performed adjusted for the confounders age, sex, expertise, experience, and initiation-age with an interaction term between EMC and DMC to assess effect modification.

189 dancers (26.7 ± 7.9 years; 130 professionals, 27 nations) reported 197 acute and 465 overuse injuries (previous two years). Mean EMC was 3.1 ± 1.07 , DMC 3.3 ± 1.08 . EMC was associated with less acute ($\beta = -0.22$; 95%CI -0.40 to -0.04) and overuse injuries ($\beta = -0.74$; 95%CI -0.99 to -0.50), while DMC was associated with more injuries (acute: $\beta = 0.30$; 95%CI 0.13 to 0.47; overuse: $\beta = 0.74$; 95%CI 0.50 to 0.98). When tested together and adjusted for confounders, EMC lost its protective effect (acute: $\beta = -0.15$; 95%CI -0.19 to 0.49; overuse: $\beta = -0.34$; 95%CI -0.81 to 0.12). DMC was positively associated with injuries throughout all settings (acute: $\beta = 0.43$; 95%CI 0.10 to 0.76; overuse: $\beta = 0.46$; 95%CI 0.00 to 0.91). EMC showed no moderating effects on DMC in the adjusted models.

It can be concluded that it is not enough to create an EMC in order to avoid injuries in dancers, which is but contra-effected in the presence of a DMC. Ballet-teachers/masters should avoid DMC altogether to prevent injuries in dancers.

In sports science, neuromuscular warm-up exercises (NM-WU) have shown to prevent injuries. In dance, research on WU is scarce. Hence, in Chapter 4, we investigated WU habits among ballet dancers, and evaluated if NM-WU is associated with less overuse or acute injuries compared to traditional-ballet-specific-WU (TBS-WU).

In a cross-sectional survey study among ballet dancers (>18 years) acute and overuse injuries sustained in the previous two years were reported per body part. WU behavior was assessed through 28 items. Dancers were grouped into NM-WU or TBS-WU. NM-WU was based on NW-WU programs in sports science and included exercises improving strength, power, proprioception, sensorimotor control, or cardiovascular endurance. TBS-WU consisted of exercises such as stretching, dance-technical exercises, marking steps/running-through-choreographies, and stretching with weights or tools. Separate linear regression analysis adjusted for confounding were performed for acute and overuse injuries.

192 dancers (26.7 ± 7.82 years, 159 females, 132 professionals) reported 203 acute and 469 overuse injuries during the past two years. 47.4% of the dancers always warmed-up (mean duration 20.7 ± 13.2 minutes); 9.4% never warmed-up. Stretching (63%), technical-exercises (58.9%), strength-training (54.7%), and the barre (53.6%) were most often mentioned.

145 dancers did combined exercises. 31 dancers (16.15%) classified for TBS-WU, 16 dancers (8.3%) for NM-WU. NM-WU was associated with less overuse injuries compared to TBS-WU ($\beta = -2.34$; CI95% -3.54/-1.14). No association was found between the different warm-up protocols and acute injuries.

As in athletes, NM-WU might be protective against overuse injuries in dancers. Large-scale prospective cohort studies are needed to gain more insight into NM-WU as possible means of injury prevention in ballet.

As previous research as well as our investigations have shown, ballet dancers have a high injury risk. In Chapter 5, 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 (52.9%) in the per-injury and per-dancer analysis. 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 ($n=107$; 65.2%). Other causes were previous/repetitive injuries (acute-per-dancer: 35.3%, acute-per-injury: 36.1%, overuse-per-injury: 46.3%, overuse-per-dancer: 62.2%) or erroneous

dance technique (acute-per-dancer: 23.6%, acute-per-injury: 35.3%, overuse-per-injury: 47.8%, overuse-per-dancer: 53.0%). 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.

In a longitudinal cohort study presented in Chapter 6, we prospectively investigated the stress levels dancers perceive after injury and whether those stress levels are different for first-time injury and consecutive injuries.

From 2016 through 2022, five cohorts involving 145 Bachelor dance students were prospectively followed during their respective first academic year. Baseline characteristics were recorded during their first month of year, respectively. The "Performing artist and Athlete Health Monitor" (PAHM) which includes the VAS pain scale, the VAS stress scale, and the "Oslo Sport Trauma Research Center Questionnaire on Health Problems" (OSTRC) served as assessment tool. Stress levels, injuries and injury severity were reported monthly and recorded throughout the academic year. For stress analysis, the first-month stress assessment in September served as baseline in which dancers had to be injury free to be included in this analysis. Paired t-tests were conducted to investigate the difference between baseline and first as well as consecutive injuries, respectively.

67 dancers with a mean age of $18.8 \pm .80$ years (58.2% female) sustained at least one injury. 46 of them sustained at least one consecutive injury. OSTRC severity scores

ranged from a mean of 28.7 ± 17.5 for first injuries to 31.4 ± 17.1 for consecutive injuries. The mean baseline stress level for injuries was 25.3 ± 17.7 . Dancers' stress levels during first and consecutive injuries were elevated compared to the baseline stress levels, 34.0 ± 18.1 and 34.2 ± 21.6 , respectively. There were no differences between stress levels during first and consecutive injuries. We therefore conclude that injuries are associated with increased stress levels in dancers, but stress levels were equally high after first and consecutive injury in contrary to previously found results in other athletes. We emphasize the importance of a holistic approach to injury rehabilitation, including dancers' psychological recovery and a focus on stress management.