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ORIGINAL ARTICLE

# Acute Injuries in Student Circus Artists with Regard to Gender Specific Differences

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## Abstract

***Purpose*: Student circus artists train as both artists and athletes with their bodies holding the key to professional success. The daily training load of student circus artists is often associated with maximum physical and psychological stress with injuries posing a threat to a potential professional career. The purpose of this study is the differentiated analysis and evaluation of work accidents in order to initiate the development of injury preventive programs.**

***Methods*: The 17 years of data were obtained from standardized anonymous work accident records of the Berlin State Accident Insurance (UKB) as well as a State Artist Educational School (n=169, Male: 70; Female: 99) from student artists. Evaluation and descriptive statistics were conducted with Excel 2007 and PASW Statistics 18.**

***Results*: The injury risk seems to be relatively low (0.3 injuries/1000h). There are gender specific differences as to the location of injuries. Only 7% of the accidents demand a break of more than 3 days. Injury patterns vary depending on the activity and the employment of props/equipment. 75.2% of work accidents have multifactorial and 24.8% exogenous causes.**

***Conclusions*: Because physical fitness is all important in the circus arts there are numerous options for injury prevention programs that should be realized subject to gender-specific differences. Follow-ups on chronic complaints and a more individual approach are indispensable due to the very specific activities in the circus arts.**

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## INTRODUCTION

The acrobatic training affects the entire way of life[1]. It is characterized by extreme forced postures and movements [2]. The necessary skills are acquired daily by several hours of training over a long period. The high physical stress takes place in a period of changes in adolescents subject to the age of puberty. Despite the athletic attributes of acrobats, there are only few studies and all but two [3,4] are very old[5-7]. As the body is all important for professional training and the subsequent career, it is vital to improve the knowledge on injury risks for adolescent circus arts students undergoing a professional training. This would allow early and successful individual injury-preventive measures. The aim of this study is to present differentiated data on acute injuries in the training period. Of great interest is the question whether characteristic health dangers (e.g. work contexts, work locations, time parameters) that are associated with an increased injury risk, could already be defined for the training period. In addition to that, it should be investigated whether there are significant gender-specific differences already in adolescents.

## METHODS AND SUBJECTS

The basis for this retrospective descriptive epidemiologic study is the number and type of work accidents in circus arts students of a state training school (n=169, male: n=70, female: n=99) aged between 11 and 22 years. According to the State Accident Insurance a work accident is defined as 'a time-limited incident affecting the body during work or on the way to work or home'. Each work accident involves a consultation with a medical doctor, who is authorized to deal with occupational accidents. All work accidents were registered in standardized work accident reports (F1000) as well as in exposure data from the Berlin State Accident Insurance (UKB) over a period of 17 years.

The registration and administration of the work accidents is centralized at the Berlin State Accident Insurance (UKB) and not accessible to the public. All students of the state school are compulsory members of the UKB. Analyzing the causes, endogenous (nutritional and training status, physical prerequisites and technical skills of the student) and exogenous (training plan, microclimatic conditions, lighting, partner, props/ equipment, costume, floor)[8] factors can be differentiated[8]. The data were evaluated anonymously.

Due to the research design, neither permit from the Ethics Committee nor from the Institutional Review Board was required. From a data protection perspective this data does not require any particular protection for they are not personal data. Data were calculated using the PASW Statistics software package, Version 18.0 and Excel 2007. Predominantly, the evaluation was done in form of frequency analyses. Chi-Square Tests were used at crucial points to evaluate the differences between the groups. The significance level was set at $\alpha$=0.05.

## RESULTS

An average of 10 work accidents occur annually (0.3 injuries/1000h). With an average of 30 students per academic year one in three circus arts students sustains a minimum of one acute injury per year with only 2.8% of the injuries categorized as "severe". The highest percentage of acute injuries is categorized as 'minor' (83.3%) and 'mid-level' (13.9%) – according to the General (Artistic Non-Specific) Degree of Severity of the UKB that considers the type of injury, the resulting costs as well as the duration of treatment. Gender-specific differences as to the degree of severity could not be ascertained.

### *Location of the accident:*

Of all work accidents 87.0% occur in the gym. 5.9% at places not associated with the physical training (e.g. corridors, showers, stairs, doors, class rooms). 3.6% in the ballet studio and 1.8% on the way home or to work and during rehearsals and guest performances. The most common accidents (88.8%) are observed during the artistic training, 0.6% during explicitly named rehearsals, 1.2% during performances. but those are very rare during the training period. Of all work accidents 9.5% are not sustained during the training but at school camps, during breaks, on the way home or to work or during theoretical lessons.

During the technical-physical training almost half of the work accidents (50.3%) in either sex can be assigned to floor acrobatics, 10.3% to the tightrope/skipping rope/slack-line and 9.1% to the trapeze. Approximately one in 10 work accidents (9.7%) is neither sustained by floor condition nor by pieces of equipment/ props.

### *Types of injury and injured structures:*

Of all injuries sprains, minor contusions and strained/pulled muscles are the most common types of injuries in either sex (Table 1).

No significant gender specific differences are observed here ($P$=0.2). The individual structures significantly differ as to the frequency of injuries ($P$<0.001). Only 7% of all injuries result in an absence exceeding more than three days from training.

### *Location of injuries:*

Gender-specific differences due to the location are observed, even when these results are statistically not significant ($P$=0.6) (Fig.1 and 2).

The gender-specific differences in the lower

**Table 1:** Types of injury and injured structures (n=169)

| Injury | | Total % (n=169) | Male % (n=70) | Female % (n=99) |
|---|---|---|---|---|
| Type of injury | Sprain | 28.2 | 29.4 | 27.4 |
| | Contusion | 26.4 | 26.5 | 26.3 |
| | Wound | 3.7 | 5.9 | 2.1 |
| | Strained/pulled Mscle | 28.2 | 26.5 | 29.4 |
| | Fracture | 9.2 | 8.8 | 9.5 |
| | Luxation | 1.8 | 0.0 | 3.2 |
| | Other | 2.4 | 2.9 | 2.1 |
| Injured structure | Joint | 48.8 | 46.5 | 50.5 |
| | Bone | 23.8 | 23.9 | 23.7 |
| | Ligament | 14.9 | 14.1 | 15.5 |
| | Skin | 5.4 | 5.6 | 5.2 |
| | Muscle | 7.1 | 9.9 | 5.2 |



extremity result from injuries in the knee joint region (m: 12.9%. f: 8.6%) and foot region (m: 12.9%. f: 6.5%). In all work accidents, the right (39.9%) and left (32.0%) side of the body was affected (Table 2).

***Comparing floor acrobatics to acrobatics with equipment/props:***

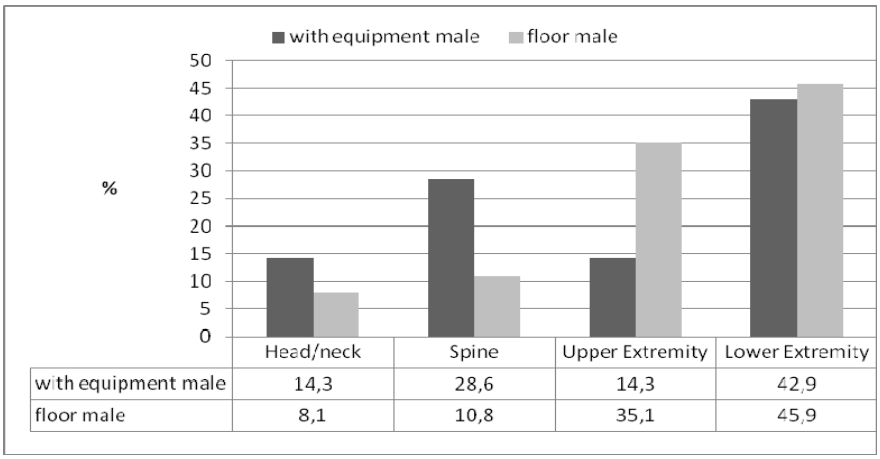
There are differences in injury regions comparing floor acrobatics with those using equipment/props (e.g. trapeze, tightrope, slack-line) (Fig. 3).

Although the gender specification is less remarkable, it is apparent, however, not statistically significant (*P*=0.4). The lower extremity is the most commonly damaged anatomic region (37%) in acrobatics with equipment/props. In the overall assessment, however, various spinal sections are affected (28.3%) (cervical spine: 17.2%, thoracic spine: 0%, lumbar spine (LS) 10.9%), followed by the upper extremities (19.6%). In 15.2% of all work accidents the head area is affected.

Whilst in acrobatics with equipment lower extremity injuries sustained by female student circus artists are rare, almost twice as many (m) and more than twice as many (f) head injuries are observed compared to floor acrobatics (equipment: m: 14.3%. f: 16.1; floor: m: 8.1%. f: 7.7%) due to the direct head contact with the equipment (e.g. trapeze). Likewise, spine injuries in student circus artists training with equipment are three times as many (m), twice as many (f) resp. as in floor acrobatics (equipment: m: 28.6%. f:

**Table 2:** Location of injury and injured structures (n=169)

| Location | Male % (n=70) | Female % (n=99) |
|---|---|---|
| Head/neck | 10 | 12.9 |
| Cervical spine | 4.3 | 10.8 |
| Thoracic spine | 0 | 0 |
| Lumbar spine | 11.4 | 7.5 |
| Hip | 1.4 | 3.2 |
| Thigh | 1.4 | 1.1 |
| Knee joint | 12.9 | 8.6 |
| Lower leg | 0 | 0 |
| Ankle joint | 18.6 | 17.2 |
| Foot | 12.9 | 6.5 |
| Shoulder/upper arm | 4.3 | 14 |
| Lower arm/wrist | 5.7 | 8.6 |
| Hand | 14.3 | 8.6 |
| Trunk | 2.8 | 1.1 |




| | Head/neck | Spine | Upper Extremity | Lower Extremity |
|---|---|---|---|---|
| with equipment male | 14,3 | 28,6 | 14,3 | 42,9 |
| floor male | 8,1 | 10,8 | 35,1 | 45,9 |



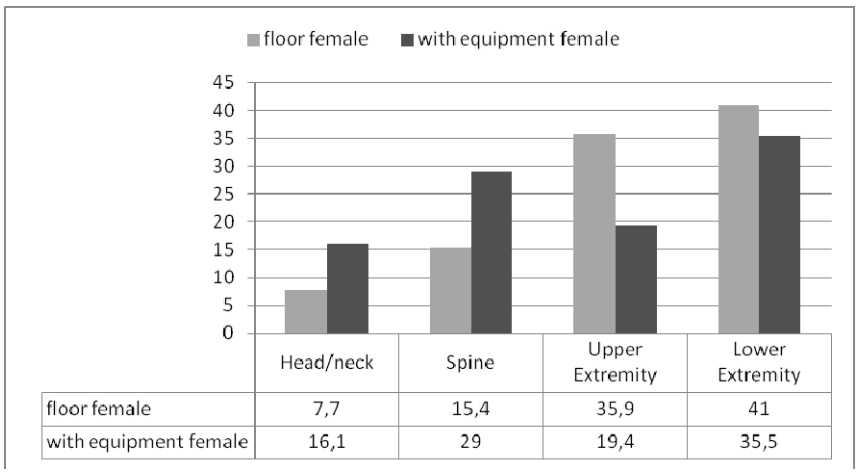
**Fig. 1:** Locations of injuries differentiating equipment and floor acrobatics in male circus arts students (n=70)

29.0%; floor: m: 10.8%. f: 8.4%). The cervical spine is the most commonly injured and most fragile region in either sex (m: 14.3%. f: 19.4%) for one in five work accidents affects the cervical region. Furthermore, it is noticeable that the upper extremity injuries sustained on the floor are almost twice as many (f), more than twice as many (m), resp. compared to injuries with equipment.

***Time of the work accident:***

The injury rate in the circus arts field is relatively evenly distributed with slight fluctuations during the school year with 25.9% (1st quarter), 21.6% (2nd quarter), 20.4% (3rd quarter) and 32.1% (4th quarter) ($P$=0.1). Due to the summer intermission the injury rate is low in the 3rd quarter ($P$<0.001). Most injuries are sustained in the months after the summer intermission with 16.0% in September, followed by November (12.3%) and October (11.1%).

During the day, periods of significantly ($P$<0.001) higher injury risks are observed (Fig. 3). Even more distinctive than the time of the day, is the period between the beginning of the training day and the time of the work accident which is reflected in the injury rate: Of all accidents, 41.8% are sustained in the first two lessons after the individual beginning the training. A further increase of the injury rate can be observed near the end of work or end of training, i.e. in the




| | Head/neck | Spine | Upper Extremity | Lower Extremity |
|---|---|---|---|---|
| floor female | 7,7 | 15,4 | 35,9 | 41 |
| with equipment female | 16,1 | 29 | 19,4 | 35,5 |

**Fig. 2:** Locations of injuries differentiating equipment and floor acrobatics in female circus arts students (n=99)

**Fig. 2:** Trapeze acrobat in action



period between 6 to 8 hours after beginning of the training. Of all work accidents occurring during the day 17.6% are sustained then. Of all injuries 35.9% are sustained in the first two years after starting the training at the school with 15.8% in the first year.

***Age:***

Looking at age in a non gender specific manner (across sex), more than half (56.4%) of all injuries are sustained between the 15$^{th}$ and 17$^{th}$ year of life. Of all injuries in female students the most common are sustained in the 15$^{th}$ and 17$^{th}$ year of life (23.3%). The highest injury rate with almost one quarter (23.9%) can be observed in male students sometime later compared to female students.

***Activity and movements during the work accident:***

Jumps are the significantly ($P$<0.001) most common movements in either sex to result in work accidents (m: 35.2%. f: 37.5%), followed by circular movements/ rotations (also vertical spins without floor contact) (m: 22.5%, f: 24.0%) and plain/simple walking and running movements as well as simple dance steps combinations (m: 11.2%, f: 12.0%). On the whole, there is a wide variety of physical activities (movement contexts) that may result in an accident.

Falling and tumbling are the significantly (p<0.001) most commonly movements resulting in injuries (m: 32.4%. f: 33.1%), followed by the classical inversion sprain (‘twisting ones ankle‘) of the ankle joint (m: 21.1%. f: 21.1%), an ‘overstretching‘of muscles (m: 14.1%. f: 14.0%), ‘being hit‘ (m: 12.7%. f: 12.1%) and ‘technically deficit landings’ (m: 11.3%. f: 11.2%) (Table 3).

***Causes:***

Of all work accidents, 75.2% (m: 76.8%. f: 74.0%) are multifactorial (e.g. choreographic and technical training, and nutrition state, time of day, degree of fatigue), without being in a position to clearly define the cause – the so called object that caused the work accident ($P$<0.001). Almost one in four work accidents (24.8%) is initiated by a definably exogenous cause, 15.9% (m) 20.8% (f), resp. are initiated by the

**Table 3:** Movement resulting in an acute injury in circus arts students

| Movement | Male (n=70) | Female (n=99) |
|---|---|---|
| **Falling** | 32.4 | 33.1 |
| **Getting caught** | 1.4 | 1.4 |
| **Twisting** | 21.1 | 21.6 |
| **Landing** | 11.3 | 11.5 |
| **Pushing** | 5.6 | 5.7 |
| **Being hit** | 12.7 | 12.9 |
| **Overstretching** | 14.1 | 14.4 |
| **Slipping** | 1.4 | 1.4 |

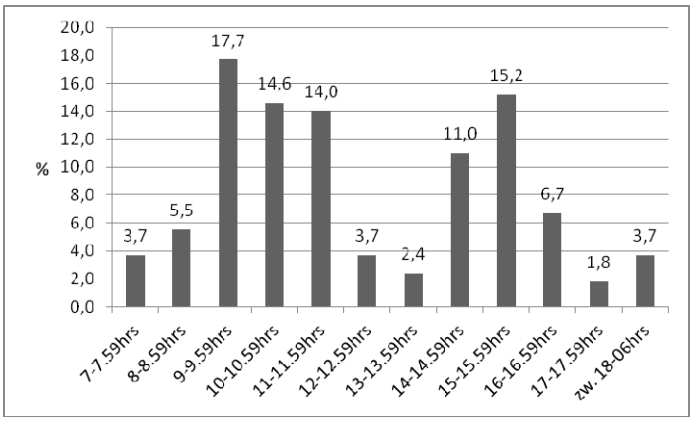



**Fig. 3:** Time of occupational accident in circus arts students (n=169)

equipment, props used and 2.8% (m) 1.0% (f), resp. by the partner.

## DISCUSSION

The restrictions in the comparability of circus artists and other athletes result from their very different physical and artistic characteristics. Therefore, circus artist students are to be analyzed and evaluated as an individual/autonomous group [1,2,9,10].

The acute injury rate is very low despite the intensive and monospecific training, and an increase of requirements to ensure the competitive capability observed in recent years [11]. The results show a slight overbalance of lighter injuries [3] and only one in twelve accidents resulted in a training interval of more than 3 days. The low injury rate corresponds with results from the professional dance [12,13] and dance student level [10]. Each injury represents a potential danger to a career that has not yet begun [13]. Due to high work load intensity and duration – as in professional dance [14-18] chronic and overuse injuries can occur [2,3,4]. Neither have they been considered in previous studies nor in this one. These should be the subjects of future focus. Compared to professional dance, apparatus gymnastics and numerous other types of sports, the lower extremity is the most commonly injured area during the training to become a circus artist [19,20]. Hardly any gender specific differences are observed in injury type, injured structure, causes, movement during the work accident and the activity before the accident. It is obvious that female students had a higher proportion of upper extremity injuries. These injuries in female students may result from the high workload as well as from the discrepancy between the degree of difficulty and the muscular stabilization capability and power capability together with the simultaneous hypermobility in extreme ranges of movement that are required in the circus arts [2,21]. Particularly in growth periods this mobility increases a temporary instability and imbalance and may result in a higher susceptibility to injuries/injury risk [30-32]. The same could be valid for the high proportion of their knee and foot injury rates. However, it should be considered that the landings after jumps drive high forces through the musculoskeletal system.

In almost one in three accidents the spine is affected in male and in one out of five accidents the cervical spine is affected in female students. The spine is the most sensitive part of the musculoskeletal system and should be focused on during circus arts training. According to Kahle [2], repeated smaller injuries result in degenerative changes [22]. The relevance of this finding is emphasized by the present study. Above all, weight, concussion and jolt expositions should be minimized [23].

Furthermore, it is to be taken into account that acute injuries may result from chronic unresolved problems that have been compensated for. An additional overall strength, conditioning and fitness coaching with stability and coordination training could be an initial step toward a successful injury prevention program [24-

[27]. Depending on the time of the day the injury risk is increased while performing demanding movement combinations without a sufficient aerobic basic endurance status [28,29]. This may be the case for circus artists too, but there are little or no data on the cardiopulmonary capability.

The majority of injuries is multifactorial. Thus, the causes – as in professional dance – are on the one hand endogenous (nutritional and training status, physical prerequisites and technical skills of the student) and on the other hand exogenous (training plan, microclimatic conditions, lighting, partner, props/equipment [8]. As in professional dance an influence of equipment on the injury patterns becomes apparent [33,34]. Thus, injury prevention comprises several aspects.

Time-related frequencies of injuries can be observed in circus arts students to overlap with those in professional dancers [35]. Here, an adaptation to training intensity is required.

In the long run, injury - and work accident risks can only be reduced in circus arts students that entirely correspond to the anatomic-physiological and aesthetical aptitude criteria for a professional circus arts training, without having to adjust measures or methods [36]. Any type of compromise, either by dietetic measures to correspond to the physical ideal, or by compensation mechanisms to perform a technique due to physical restriction results in an increased accident risk [37,38].

Unlike in professional dance, the majority of injuries in circus arts students is sustained at non dance specific locations such as stairs, halls and showers and when executing non dance specific activities [34]. These results explain the necessity not to exclusively limit injury prevention to training, for accidents occur at non specific locations, too.

Ignoring smaller injuries increases the risk to sustain a follow-up injury. Trivializing and not reporting a work accident can not be ruled out although it is mandatory. However, as minor injuries in acrobatics (e.g. in the trapeze) may result in life threatening situations, an almost complete case number can be presumed. In contrast with self reported questionnaires that consult personal assessments, objective findings were evaluated in the present study. Beyond the circus arts field, there are no direct comparative populations except elite gymnasts and professional dance students. The restrictions in the comparability of circus artists and other athletes result from their very different physical and artistic characteristics. Therefore, circus artist students are to be analyzed and evaluated as an autonomous group [1-3].

## CONCLUSION

Improvements to context, timing, schedules, training and nutrient status by management/teachers/physical educators could contribute to further reduce injury rates. The monospecific training concept should be reviewed and sports medicine findings integrated, as was already recommended more than 40 years ago by Heiß [23].

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