



# Types, frequencies and burden of health problems in elite luge athletes: a 46-week prospective cohort study

Sarah Christina Tomaselli <sup>1</sup>, Rohit Arora,<sup>2</sup> Elias Mühlbacher,<sup>3</sup> Armin Runer,<sup>4,5</sup> Friedemann Schneider <sup>2</sup>

**To cite:** Tomaselli SC, Arora R, Mühlbacher E, *et al.* Types, frequencies and burden of health problems in elite luge athletes: a 46-week prospective cohort study. *BMJ Open Sport & Exercise Medicine* 2024;**10**:e002055. doi:10.1136/bmjsem-2024-002055

► Additional supplemental material is published online only. To view, please visit the journal online (<https://doi.org/10.1136/bmjsem-2024-002055>).

Accepted 12 September 2024



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<sup>1</sup>Medical University of Innsbruck, Innsbruck, Austria

<sup>2</sup>Department of Orthopaedics and Traumatology, Medical University of Innsbruck, Innsbruck, Austria

<sup>3</sup>Leopold-Franzens-University Innsbruck, Innsbruck, Austria

<sup>4</sup>Department of Orthopaedic Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

<sup>5</sup>Department of Sports Orthopaedics, Technical University of Munich, München, Germany

## Correspondence to

Dr Friedemann Schneider; [friedemann.schneider@i-med.ac.at](mailto:friedemann.schneider@i-med.ac.at)

## ABSTRACT

**Background** There is a research gap in the survey of injuries and illnesses in the sport of luge.

**Objective** To analyse the type, frequency and burden of injuries and illnesses that occurred over a preparation period and a competition period in elite luge athletes.

**Methods** In total 40 elite luge athletes, who were all part of a national team and competed internationally, self-reported acute injuries, overuse injuries and illnesses weekly using the Oslo Sports Trauma Research Centre Questionnaire on Health Problems.

**Results** The most frequently stated health problems were illnesses with 41.9% (n=75), followed by acute injuries at 31.9% (n=57). Overuse injuries accounted for 24.0% (n=43). Illnesses represented the greatest burden with a median severity score of 60.0 (IQR: 23.63), followed by acute injuries with 42.0 (IQR: 26.83) and overuse injuries with 35.0 (IQR: 23.95). In the case of acute injuries, the anatomical regions most affected were the hand (n=8, 14.0%), foot (n=8, 14.0%), head (n=7, 12.3%) and neck (n=6, 10.5%). In the case of overuse injuries, the shoulder (n=9, 20.9%) and lumbar spine (n=7, 16.3%) were most frequently reported. Strains (n=15, 26.3%) and contusions (n=14, 24.6%) were the predominant types of acute injuries. Four concussions were recorded, with none of the athletes taking a break from normal training of more than 3 days. This stands in contrast to the current recommendations for the return to sport after concussion.

**Conclusion** The results of this study represent the current incidence rates and health burden of acute and chronic injuries in this constantly evolving sport. 95% of all athletes reported at least one health problem during the observation period. These findings support the need for specific prevention programmes. The establishment of a concussion protocol should be considered.

## INTRODUCTION

Luge has been an Olympic sport since 1964. On the track, athletes can reach speeds up to 150 km/hour.<sup>1</sup> At such high speeds, there is a potential risk of injury, especially in the case of collisions. Mandatory protective gear only includes wearing a helmet.<sup>2</sup> In addition to the run itself, the starting process also possesses a relevant risk of injury due to the high loads acting on the shoulder and the lumbar spine (figure 1).

## WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The most recent epidemiological study on injuries in the sport of luge was published over 25 years ago and solely addressed injuries sustained during a run. Following the 2010 and 2014 Winter Olympics, luge was categorised as a sport with a minimal risk of injury. Due to the lack of research in the field of Olympic luge, very little is known about the most common and typical injuries in this sport.

## WHAT THIS STUDY ADDS

This study provides a comprehensive overview of health problems in the sport of luge and highlights the most common injuries:

- ⇒ The most common acute injuries are to the hand, foot, head and neck region.
- ⇒ Regarding overuse injuries shoulder and lumbar spine are the most frequently affected regions.
- ⇒ Contusions and strains are the most commonly reported type of injury.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The findings support the need for targeted prevention programmes for both acute and overuse injuries. An adaptation of the protective equipment should be discussed. In addition, the implementation of a concussion protocol should be considered.

After the 2010 and 2014 Winter Olympics, luge was classified as a sport with a low risk of injury despite a fatal accident of a Georgian athlete during a training run for the 2010 Winter Olympics.<sup>3–6</sup> Furthermore, luge was the ice sport with the lowest injury incidence rate (IRR 7.4%) among those included in the study (bobsled, skeleton, luge) at the Olympic Games between 2010 and 2018.<sup>7</sup>

The last epidemiological study specifically on injuries in the sport of luge was published more than 25 years ago<sup>8</sup> and only covered injuries that occurred during a run. This is particularly remarkable for a sport that has experienced considerable technical progress and further developments during this time period. In general, luge has received the least



**Figure 1** (A) Luge athlete in the driving position on a straight section of the track in Altenberg, Saxony, Germany. (B) Luge athlete during the starting process at the doubles start in Altenberg, Saxony, Germany.

attention among all Olympic winter sports, with only six publications to date.<sup>9</sup> The lack of research is evident when compared with other well-studied sports such as ice hockey, snowboarding or skiing.<sup>9</sup>

It can be observed that the performance level in this sport is constantly increasing. In addition, the training has been adapted to the increasing level. In summary, these points indicate that the existing evidence regarding injury epidemiology in this sport may no longer be entirely up to date. The aim of this study was, therefore, to find out which types of health problems occur most frequently in this specific sport and whether there is an increased potential for overuse injuries in addition to the risk of acute injuries.

## METHODS

### Study design and participants

This prospective cohort study involved athletes from five different countries over an observation period of 46 weeks.

The cohort was composed as a convenience sample and mainly included acquaintances, particularly of the first author, who herself was a professional luge athlete for several years. Athletes from Austria, Germany, Italy, Switzerland and the UK were included. All participating athletes spoke German as their mother tongue. The participants were sent a weekly questionnaire to assess their current health problems. The study was carried out between April 2022 and March 2023 and included a preparation phase in summer and a competition phase in winter. The period from April 2022 to October 2022 (23 weeks) marked the preparation phase. The initial training on the luge track marked the beginning of the competition phase, which also lasted 23 weeks and commenced in October 2022 and concluded in March 2023.

### Recruitment and inclusion criteria

Three inclusion criteria were established prior to this study: age over 18, active in the sport of luge and being a member of a national team.<sup>10</sup> As all the athletes belonged

to a national team and competed in international tournaments, a uniform level of performance was assumed to allow an assessment of how common health problems are among athletes at the highest level of performance.

### Injury and illness data collection

The online survey programme SoSci Survey (<https://sosci.i-med.ac.at/admin/index.php>) was used for the data collection. The questionnaire was based on the Oslo Sports Trauma Research Centre Questionnaire on Health Problems (OSTRC-H).<sup>11</sup> The survey was conducted on a weekly basis to avoid under-reporting of existing health problems. A previous study about the methodology for recording overuse injuries in sport concluded that collecting data over a longer period of time results in fewer health problems being reported, particularly regarding overuse injuries.<sup>12</sup> The questionnaire was sent every Sunday so the athletes could report on the previous week. A reminder email was sent on Wednesdays and Fridays to those athletes who had not yet completed the questionnaire. The questionnaire was available as a desktop and a mobile version.

A total of 50 athletes met the established criteria for participation. Of these, 40 (80.0%) consented to take part in the study. As only German-speaking athletes agreed to participate, it was decided to use the already validated German-translated version of the OSTRC-H.<sup>13</sup> The OSTRC-H contains four questions regarding participation in training and competition, the extent of symptoms, reduction in training intensity and performance hindrance attributed to a health problem preceding 7 days.<sup>11</sup> These four questions form the basis for calculating a severity score for every reported health problem.<sup>11</sup> Furthermore, the athletes were asked to specify the type of health problem they were dealing with, whether it was an illness, an acute injury, or an overuse injury. Depending on the health problem in question, the athletes were asked to specify which body region or system was affected. They were also asked to provide information regarding time loss and whether they required medical attention.

A health problem was further classified as a substantial problem if the injury or illness resulted in a mild or severe reduction of training or competition performance or completely inhibited the participation in training or competition.<sup>11 14</sup>

### Definition and classification of health problems

We followed the International Olympic Committee's Consensus Statement for the definition and categorisation of a health problem.<sup>15</sup> In the injury survey, a distinction was made between acute injuries, overuse injuries and pre-existing injuries. The main criterion for differentiation was whether the injury occurred suddenly and could be attributed to a specific event or whether the injury had developed gradually over a long period of time without a single event being the cause. The use of an additional category of pre-existing injuries improved the differentiation between acute, subacute and chronic complaints. This classification covered all health problems and did not affect the incidence measures.

### Incidence and relative burden of acute injuries, overuse injuries and illnesses

The incidence rate was calculated from the number of new health problems per week. The number of newly reported acute injuries, overuse injuries and illnesses was divided by the number of responses recorded each week to derive the incidence per health problem per week. Following the weekly incidence calculations, mean values were determined for acute injuries, overuse injuries and illnesses. The mean values were multiplied by 52 in order to calculate the incidence per year for each health problem. The online programme GraphPad (GraphPad Software, Boston, Massachusetts, USA) was used to calculate CIs under the assumption of the Poisson distribution. In this study, the burden for each health problem was defined as the respective relative proportion of the cumulative severity score and calculated by summing the severity scores of the individual health problems and dividing those by the cumulative severity score. In addition, a median severity score with an IQR was calculated per health problem.

Furthermore, the time loss reported by the athletes for each health problem was used to determine the severity of the health problem based on the time loss. The severity of each injury and illness was categorised as slight (0 days), mild (1–7 days), moderate (8–28 days) or severe (>28 days).

### Statistical analyses

Data analysis was performed by using Microsoft Excel V.16.75.2 (Microsoft, Redmond, Washington, USA), the statistical software IBM SPSS Statistics V.29 (IBM) and RStudio V.2023.09.1+494 (RStudio Public Benefit Corporation, Boston, Massachusetts, USA). Comparative assessments between male and female athletes and the preparation and competition phase were conducted using Welch's two-sided t-tests and ORs accompanied by

**Table 1** Sociodemographic data of the study population<sup>10</sup>

	Minimum	Maximum	Mean	SD
Female (n=16)				
Age (years)	18.0	27.0	21.94	2.645
Training state (years)	7.0	19.0	12.34	3.069
Weight (kg)	60.0	78.0	68.65	5.023
Height (cm)	163.0	185.0	173.06	5.882
Male (n=24)				
Age (years)	18.0	34.0	24.83	3.874
Training state (years)	7.0	22.0	13.79	3.934
Weight (kg)	73.0	100.0	86.15	8.363
Height (cm)	166.0	191.0	182.08	6.269

95% CI. P values were determined at a significance level of 95%.

## RESULTS

### Study population

40 athletes (16 female and 24 male athletes) participated in this study. Sociodemographic details of the study population are presented in [table 1](#). Among these 40 athletes, 20 athletes competed in singles, 16 in doubles and 4 participated in both disciplines.

### Response rate

The average response rate was 78.0% (range: 60.0%–95.0%) over the 46 weeks of the observation period. In the preparation phase (weeks 1–23), the mean response rate was 82.2% (range: 75.5%–95.5%). During the competition phase (weeks 24–46), the mean response rate declined to 73.8% (range: 60.0%–85%). It should be noted that no survey was possible in week 9 due to technical problems with the server on which the survey was conducted.

### Number, incidence and time loss of health problems

A total of 179 health problems were reported. Illnesses represented the largest proportion with 75 cases (41.9%), followed by 57 acute injuries (31.9%) and 43 cases of overuse injuries (24.0%). Four health problems (2.2%) were reported without further information. This corresponds to an incidence of 2.0 new acute injuries per athlete per year, 1.5 new overuse injuries per athlete per year and 2.7 illnesses per athlete per year ([table 2](#)). Looking at the median time loss for each health problem, illnesses accounted for the highest time loss with a median of 9.0 days (IQR: 10.3, range: 0–28 days) per case. Acute injuries resulted in a median time loss of 2.0 days (IQR: 2.0, range: 0–46 days), while overuse injuries resulted in a median of 2.0 (IQR: 4.0, range: 0–14 days) days lost.

### Types and frequencies of health problems

With 75 cases, illnesses were the most common health problem. Of these, the respiratory system (n=62, 82.7%) was most frequently affected. Furthermore, a total of



**Table 2** Incidence, total time loss and cumulative severity score of health problems<sup>10</sup>

	N	Incidence rate (95% CI)	Total time loss (days)	Cumulative severity score
Illness	75	2.65 (2.3 to 3.0)	350	4564.0
Acute Injury	57	2.03 (1.8 to 2.3)	107	2409.8
Overuse Injury	43	1.51 (1.3 to 1.8)	51	1733.9
Total	179*	6.19 (5.7 to 6.7)	508	8707.7

\*Four health problems were reported without specifying the type of the problem.

57 acute injuries were documented. The most affected anatomical regions were the hand (n=8, 14.0%), wrist (n=6, 10.5%), foot (n=8, 14.0%), head (n=7, 12.3%) and neck (n=6, 10.5%). Of the 43 overuse injuries documented, the shoulder (n=9, 20.9%) and lumbar spine (n=7, 16.3%) were the most commonly mentioned anatomical areas. Four health problems were reported with no further information regarding the specific type of health problem. Contusions (n=14, 24.6%) and strains (n=15, 26.3%) were the most frequent types of acute injuries. Of the seven reported head injuries, four (57.1%) were attributed to a concussion.<sup>10</sup> All athletes who reported concussions received medical attention. For overuse injuries, no specific injury types were recorded.

### Severity of health problems

The total severity of an injury was quantified based on the weekly severity score, which was calculated for each health problem. Illnesses represented the largest amount of the total severity score, amounting to 52.4%. Acute injuries accounted for 27.7% of the total severity score, while overuse injuries comprised 19.9%. When calculating the total burden based on the total time loss, illnesses represented the biggest amount with 68.9% of the total time loss. Acute injuries account for 21.1% and overuse injuries depict only 10.0% of the total time loss. A median severity score of 60.0 (IQR: 23.63) was calculated for illnesses. Followed by acute injuries with 42.0 (IQR: 26.83) median severity score and overuse injuries with 35.0 (IQR: 23.95). Looking at the median severity score per injury, it became apparent that the knee (70.0 IQR: 4.0), ankle (60.0 IQR: 0.0), thoracic spine (53.0 IQR: 0.0) and lumbar spine (49.5 IQR: 21.5) injuries represented the greatest burden in acute injuries. In terms of total time lost, wrist injuries accounted for the greatest time loss (table 3). However, this was due to a single, long-lasting injury. If this injury is excluded, foot injuries are responsible for the greatest total time loss with 32 days lost (median 7.0, IQR: 4.0). In the overuse injury dataset, knee injuries are the most burdensome with a median severity score of 68.7 (IQR: 8.7), followed by injuries of the thigh (61.3 IQR: 10.8) and lumbar spine (52.6 IQR: 24.8). In terms of total time loss for overuse injuries, the shoulder was the anatomical location with the highest total time loss of 21 days and the neck the anatomical region with the highest median time loss (median: 7.0, IQR: 0.0). For illnesses, the respiratory system was by far

the most affected and resulted in a total time loss of 294 days.<sup>10</sup>

### Substantial health problems

Of 175 health problems reported 59 illnesses (78.7%), 25 acute injuries (43.9%) and 14 overuse injuries (32.6%) resulted in a mild or severe reduction of training or competition performance or even full inhibition of training participation and were defined as substantial problems. 58.7% of illnesses, 89.9% of all acute injuries and 88.4% of overuse injuries required medical attention (table 4).

### Comparison between preparation and competition phase

During the preparation phase, 43 illnesses, 23 acute injuries and 20 overuse injuries were reported.

In comparison, 32 illnesses, 34 acute injuries and 23 overuse injuries were recorded during the competition phase.<sup>10</sup> There were no significant differences between the individual phases and the occurrence of acute injuries or overuse injuries. Neck injuries were more common in the competition phase (n=10, 17.5%) than in the preparation phase (n=1, 2.3%). This can probably be attributed to the start of training on ice and the associated stress on the relevant anatomical regions (figure 1). The results also show that substantial health problems were more likely to occur in the preparation phase (n=64) than in the competition phase (n=34) (95% CI 1.13 to 2.35, OR 3.81, RR 1.63, p=0.0088). There were no significant differences between the two phases in terms of health problems requiring medical attention. Details are presented in online supplemental appendix 1 and 2.

### Gender-specific differences

No significant differences were observed between male and female athletes. Further details can be found in table 5.

Regarding the anatomical locations, there were differences in the incidence of head and neck injuries, with both types of injury being more commonly reported by female athletes. In contrast, injuries to the lumbar spine were slightly more common in male athletes. Knee injuries were only reported by male athletes (n=4) in this cohort.

**Table 3** Severity of time loss of acute injuries, overuse injuries and illnesses by region and organ system

	Cases N	Slight (0 days)	Mild (1–7 days)	Moderate (8–28 days)	Severe (>28 days)	Total time loss (days)
<b>Acute injury</b>						
Head	7	3	4	0	0	10
Neck	6	4	2	0	0	4
Cervical spine	1	0	1	0	0	2
Shoulder	3	2	1	0	0	2
Upper arm	1	1	0	0	0	0
Forearm	2	1	1	0	0	4
Wrist	6	3	2	0	1	52
Hand	8	5	2	1	0	12
Thoracic spine	1	1	0	0	0	0
Lumbar spine	2	1	1	0	0	1
Hip/pelvis	3	3	0	0	0	0
Thigh	2	2	0	0	0	0
Knee	2	0	2	0	0	6
Ankle	3	2	1	0	0	2
Foot	8	4	2	2	0	32
Other	2	2	0	0	0	0
<b>Overuse injury</b>						
Neck	5	4	1	0	0	7
Cervical spine	1	1	0	0	0	0
Shoulder	9	4	4	1	0	21
Wrist	2	2	0	0	0	0
Hand	3	3	0	0	0	0
Lumbar spine	7	3	4	0	0	9
Hip/pelvis	7	6	1	0	0	1
Thigh	2	0	2	0	0	6
Knee	2	0	2	0	0	8
Lower leg	2	2	0	0	0	0
Ankle	3	3	0	0	0	0
Foot	2	2	0	0	0	0
<b>Illness</b>						
Respiratory	62	12	40	10	0	294
Gastrointestinal	4	0	4	0	0	11
Cardiovascular	1	0	0	1	0	9
Neurological	1	0	1	0	0	1
Dermatological	1	0	1	0	0	7
Other	6	1	2	1	0	28

## DISCUSSION

The primary finding of this study was that illnesses represent the most frequently reported health problem among elite luge athletes, as well as the greatest burden. This study shows that besides illnesses athletes frequently experience acute injuries, with hand and foot injuries ranking as the most prevalent, closely followed by head and neck injuries. In terms of overuse injuries, the

anatomical regions most affected were the shoulder and the lumbar spine.

In this study, illnesses accounted for the largest share of health problems with 41.9%. During the observation period, the COVID-19 pandemic was still noticeable and must be considered as a substantial factor. Acute injuries accounted for 31.9% of all health problems while overuse injuries summed up to 24.0%. In terms of acute injuries,



**Table 4** Total number of substantial health problems and health problems requiring medical attention

	N	Substantial health problem	Medical attention
Acute injury	57	25	51
Overuse injury	43	14	38
Illness	75	59	44
Total	179*	98	133

\*Four health problems were reported without specifying the type of the problem.

67.5% of athletes reported at least one new onset acute injury. Hand and foot were the most frequently reported anatomical regions. Due to the high impact on the head and neck region mainly during the competition phase, these anatomical regions were also particularly prone to acute injuries.

The majority of reported health problems in this study were minor health issues. This finding is consistent with the investigations carried out during the Winter Olympics, where luge athletes mainly sustained injuries with no or short periods of absence (up to a maximum of 7 days)<sup>4 16 17</sup>

By calculating the severity scores, illnesses were found to be the most burdensome for the athletes, accounting for 52.4% of the cumulative severity score, followed by acute injuries at 27.7% and overuse injuries at 19.9%. Comparisons can only be made to a limited extent due to the lack of primary studies in the sport of luge. A prior

study dates back to 1997.<sup>8</sup> In this study, 1047 athletes were observed over a 7-year period.<sup>8</sup> Only injuries sustained on the luge track were reported. When comparing acute injuries, similarities to the observed cohort in this study are certainly apparent. In the present study, hand and foot injuries accounted for 14.0% each and were the most commonly reported injuries. This can likely be attributed to the exposure of the lower and upper extremities in the track. Cummings *et al*<sup>8</sup> reported that hand injuries accounted for 11.3% of all injuries. However, in the present study, foot injuries made up a larger proportion of the injuries than in the previous study (14%/6.6%).<sup>8</sup> An additional relevant difference is the occurrence of head and neck injuries in the present study and in particular concussions. When looking at acute injuries in the competition phase, it was observed that concussions accounted for 11.8% in this study, while concussions only accounted for a proportion of 2.5% in the study by Cummings *et al*.<sup>8</sup>

It is important to note that out of the seven head injuries reported, four (57.1%) were consequently diagnosed as concussions and none of the athletes paused their training for more than 3 days. This stands in contrast to the most recent Consensus Statement on Concussion in Sports,<sup>18</sup> which suggests, that athletes who have sustained a concussion should gradually return to sport in six steps after an initial period of relative rest, with each step typically requiring a minimum of 24 hours. These findings consequently indicate that there is a lack of awareness or knowledge of the potential acute and long-term effects of sports-related concussions. Overall, there is limited information regarding the frequency of concussions in sledding

**Table 5** Injury distribution for male and female athletes

	Male	Female	Total
Total athletes (%)	24 (60.0)	16 (40.0)	40 (100.0)
Total injured athletes (%)	19 (59.4)	13 (40.6)	32 (100.0)
Total injuries (%)	49 (49.0)	51 (51.0)	100 (100.0)
Total time loss injuries (%)	20 (55.6)	16 (44.4)	36 (100.0)
Total non-time loss injuries (%)	29 (45.3)	35 (54.7)	64 (100.0)
Median time loss (IQR)	2.5 (2.75)	2.0 (1.75)	2.0 (2.75)
Median n of injuries (IQR)	1.0 (2.0)	2.5 (3.5)	2.0 (3.0)
Range (injuries/athlete)	0–8	0–14	0–14
Athlete exposure (%)	6475 (55.7)	5154 (44.3)	11 629 (100.0)
Injury incidence rate	7.6	9.9	8.6
Median Severity Score (IQR)	44.0 (29.0)	35.0 (20.0)	37.15 (25.5)
Most common body sites injured (n)			
Shoulder (%)	6 (50.0)	6 (50.0)	12
Neck (%)	3 (27.3)	8 (72.7)	11
Foot (%)	5 (50.0)	5 (50.0)	10
Lumbar spine (%)	6 (66.7)	3 (33.3)	9
Hand (%)	5 (55.6)	4 (44.4)	9
Concussion (%)	2 (50.0)	2 (50.0)	4

sports. Concussion protocols are already implemented in other sports but are still not officially introduced in the sport of luge. Besides concussions, which typically result from collisions, athletes in sliding sports (luge, skeleton and bobsleigh) also report another set of symptoms popularly known as ‘sled head’.<sup>19 20</sup> Further research is needed, alongside the implementation of preventive measures to safeguard athletes’ well-being.

### Clinical implications

The results of this study represent the current epidemiological injury situation among professional luge athletes and may, therefore, serve as a basis for the development of new protective equipment to reduce and prevent injuries. For example, changing the stability of current shoe models could be considered. Such a modification could potentially lead to a reduction in the frequency of foot and ankle injuries. The introduction of concussion protocols would be beneficial for the standardised assessment and treatment of injured athletes. In summary, this study may provide valuable insights for healthcare providers involved in the care and treatment of luge athletes and could serve as a database for the development of sport-specific prevention programmes aimed at reducing infectious illnesses and acute and overuse injuries.

### Limitations

It should be noted that the total number of cases in this cohort is relatively small, as is frequently the case with studies on professional athletes. Statistical statements may potentially remain non-significant for this sole reason. Nevertheless, members of five national teams were included in this study in order to achieve the largest possible cohort. Given the limited number of athletes available in this sport and specifically at this level of performance, the sample can in the opinion of the authors not be greatly expanded. The athletes’ self-reporting of health problems could lead to some variation in the accuracy of specific diagnoses, and therefore, represents a further limitation. Nevertheless, this was deliberately chosen in order to document all injuries, even those that remained without medical attention. Potential recall bias was best accounted for by the choice of the survey interval. It should also be noted that the study was conducted during the COVID-19 pandemic, and that the proportion of time loss due to infections may potentially be overestimated, partly due to illnesses and partly due to legal requirements or due to quarantine regulations imposed by the relevant sports associations.

### CONCLUSION

The results of this study represent the current incidence rates and calculated health burden of acute and chronic injuries in the sport of luge. Overall, 95.0% of the athletes reported at least one new-onset health problem during the study period of one full season. The majority of reported health problems manifest as minor health issues. The most frequently injured body regions

were the hand, foot, head and neck in acute injuries. In overuse injuries, the shoulder and lumbar spine were the most affected regions. Contusions and strains were the most commonly reported type of injury. Prevention strategies should prioritise the adaptation of existing protective equipment to mitigate acute injuries. Additionally, the establishment of a concussion protocol should urgently be considered.

**Acknowledgements** The authors thank all athletes for their participation and valuable input.

**Contributors** SCT prepared and disseminated the survey, monitored data collection, wrote the statistical analysis plan, cleaned and analysed the data and drafted and revised the paper. She is the guarantor. RA analysed the data and revised the paper. AR analysed the data and drafted and revised the paper. EM conducted the statistical analysis and revised the draft paper. FS initiated the collaborative project, monitored data collection, analysed the data and revised the paper. All authors contributed to the interpretation of the data. All authors gave their approval to the final version of the manuscript.

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Not applicable.

**Ethics approval** This study involves human participants and was waived by the Ethics Committee of the Medical University Innsbruck (11.01.22/MJ), as this study was conducted solely on the basis of a purely voluntary survey of athletes. Participants gave their informed consent to participate in the study.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available on reasonable request.

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### ORCID iDs

Sarah Christina Tomaselli <http://orcid.org/0009-0003-1337-3746>  
Friedemann Schneider <http://orcid.org/0000-0001-6417-1675>

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