Dental Injuries on Garden Trampolines

KEYWORDS
Dental trauma
Athletic injuries
Sport equipment
Accident prevention

SUMMARY
Garden trampolines are very popular in Switzerland. Most trampoline related accidents result in fractures and soft tissue injuries of the extremities. While these types of injuries have been well investigated in numerous studies, there has been no study on dental injuries on trampolines. The aim of the present study was to investigate dental accidents on garden trampolines in Switzerland and to analyze possible influencing factors.

Data collection was carried out by analyzing aerial photographs and a questionnaire-based survey. Out of 1212 questionnaires sent out, 637 could be included in the study. The data were evaluated in terms of accident, type of trampoline (inground or onground), and whether a safety net was present.

A total of 105 trampoline accidents (16.5%) occurred, of which 23 were dental injuries (23.2%). 39.1% (n = 9) were tooth fractures, 30.4% (n = 7) were concussions, 17.4% (n = 4) were avulsions, and 13.0% (n = 3) were dislocation injuries. Teeth were predominantly impacted on the trampoline frame (26.2%, n = 6) or on a person's own knee (26%, n = 6). Dental accidents occurred 3.6 times more frequently when the trampoline was used by more than one person at a time. Dental accidents occurred 2.4 times more frequently on inground trampolines than on onground trampolines. Statistically, only the diameter of the trampoline had an influence on the frequency of accidents: larger trampolines led more frequently to accidents.

The present study showed that trampolining poses a risk of dental injury like other sports such as kick scooter riding or skiing. It is therefore important to increase parental and public awareness regarding the potential dangers of trampoline use.
Introduction

The trampoline was invented by American circus performer George Nissen in 1936. He originally designed the trampoline, patented as “tumbling device” in 1945, for acrobats (Briskin & Labotz 2012). During World War II, the trampoline was used to train fighter pilots (Eberl et al. 2009; Smith 1998). After 1940, it became a piece of sports equipment, and from the late 1970s, trampolines were increasingly found in amusement parks, schools, and daycare centers (Thi Huynh et al. 2018). Because the trampoline promotes coordination, fitness, muscle strength, and balance, it became a popular sport and recreational equipment.

Over the last twenty years, private trampolines have seen a rapid growth in popularity. According to the Swiss Advisory Center for Accident Prevention, 17% of all Swiss households with children under the age of 15 had a trampoline in 2020 (BFU 2020). However, the increasing popularity of private garden trampolines led to a concomitant rise in trampoline-related accidents.

Such accidents were first documented by Zimmerman in 1956 (Zimmerman 1956). According to the US Consumer Product Safety Commission, the most common causes of trampoline accidents nowadays are collisions with other trampoline users, rough landings while jumping, falls onto the trampoline frame or falling off the trampoline altogether (Klimek et al. 2013). To minimize the risk of accidents while trampolining, the Swiss Advisory Center for Accident Prevention has issued specific safety recommendations. These are as follows (BFU 2015):

- Supervise children
- Maintain trampoline regularly
- Jump alone
- Set up trampoline without obstacles
- Use safety net
- Do not perform flips

A Canadian study based on cross-sectional survey data reported that most parents whose children regularly use recreational trampolines lack basic trampoline safety knowledge (Benö et al. 2018). Such gaps in parental trampoline safety knowledge are likely to be an important factor in the increase of injuries sustained during children’s recreational trampoline use (Meyer et al. 2019). Considering the serious risks for injury, some healthcare professionals deem trampolines that are used for leisure activities of children as too dangerous, with some even calling for the ban of such trampolines (Eberl et al. 2009; Furnival et al. 1999; Brown & Lee 2000; Hammer et al. 1982). Between 2003 and 2009, the University hospital in Bern, Switzerland, recorded 286 trampoline accidents involving children. The number increased from 13 patients in 2003 to 86 in 2009 (Klimek et al. 2013). Today, about 95% of all trampoline accidents happen at home, with fractures and soft tissue wounds of the extremities among the most common injuries (Korhonen et al. 2018). Head injuries, on the other hand, occur less frequently, and currently no published data are available on dental injuries owing to trampoline use (Cho et al. 2019).

The aim of this study was therefore to investigate dental accidents on garden trampolines in Switzerland and to analyze possible correlative factors. The null hypothesis was that neither multi-person trampolining, nor any design or installation features of trampolines would have an association with the frequency of trampoline-related dental injuries.

Material and method

Selection of aerial photographs

In a preliminary investigation, aerial photographs of various providers were assessed regarding their suitability to visually detect garden trampolines. Images provided by map.search.ch, which are based on data from Swisstopo, the Swiss Federal Office of Topography, were deemed the most suitable for the present study. Its aerial images, acquired through airplane-based vertical aerial photography, have a ground resolution of 0.1 m and undergo regular updating (swisstopo.admin.ch).

Search for eligible households

From May to June 2020, aerial photographs of each German-speaking municipality of Switzerland were visually screened by an investigator (A WH) for private residences with a round garden trampoline. All 1438 German-speaking political municipalities of Switzerland, listed in the atlas “The 4 language areas of Switzerland by municipality 2016” published by the Swiss Federal Statistical Office, were included in the screening.

The aerial photographic map of each municipality was viewed on map.search.ch, employing the maximum zoom factor (Fig. 1). Only round trampolines were considered. Based on color and shadow features, trampolines could be distinguished from inflatable pools. In cases of uncertainty, another trampoline in the same municipality was sought out. Trampolines were ineligible for inclusion if they belonged to an apartment building or if it was unclear whose property they were located on. If the aerial photographs of a municipality featured more than one eligible private residence, one of these residences was selected at random. In some municipalities, no trampoline could be found. The addresses of the selected private residences were collected using an in-build tool of map.search.ch and stored in a purpose-built, secure database. For the avoidance of doubt, only one trampoline per municipality was selected for inclusion in our work.

Questionnaire survey

In mid-June 2020, a questionnaire was mailed to each address collected in the database. It included a hand-signed cover letter
ter, outlining the aim of the study and the irreversibly anony-
mized nature of the survey, and a self-addressed stamped envelope to reply. Owing to the voluntary nature of the survey and the irreversibly anonymized data collection, the local ethics committee waived the requirement for ethical approval (EKNZ Req–2020–00605). The questionnaire consisted of one open-ended and ten close-ended questions. The question-
naire comprised questions on design and installation features of the garden trampoline, details on persons who regularly use the trampoline and on multi-person trampolining, any trampoline-related accidents including details on the type of accident and sustained injuries. The questions included in the questionnaire are reported in Table I in detail. Questionnaires returned by the end of August 2020 were considered in the analysis.

Statistical analysis
Data from the questionnaires were recorded in an Excel spread-
sheet. Descriptive analysis included number of cases and per-
centages for categorical parameters (e.g., safety net). For con-
tinuous parameters (e.g., diameter of the trampoline), the
mean with standard deviation was calculated. Associated
p-values were calculated using appropriate significance tests (Chi² test, t-test, and Wilcoxon rank sum test). To estimate
which parameters had an influence on the occurrence of ac-
cidents, logistic regressions were calculated (accident yes versus no). The resulting estimators were odds ratios (OR) with the corresponding 95% confidence intervals and p-values. For all

test procedures, a 5% (two-sided) probability of error was set
as the significance level. Owing to the purely descriptive nature of the study, no adjustment was made for the probability of er-
ror for multiple comparisons. All analyses were carried out with the statistical program R version 3.5.1 (R Foundation for Statis-
tical Computing, Vienna, Austria).

Results
Of the 1212 letters sent out, the post office returned six undeliv-
ered letters to sender. Within ten weeks, 730 questionnaires
were returned. This corresponds to a response rate of 60.2%.
93 households replied that they either no longer owned a tram-
pole or had never owned one. A total of 637 questionnaires of
private households with a garden trampoline were available for
analysis.

Most households owned an onground trampoline (95.5%,
n = 577) with a safety net (72.1%, n = 413) (Fig. 2). The diameter
of the trampolines averaged 373.5 cm (80–600 cm, SD 81.4 cm).
The average age of a trampoline user was 14.3 years (1–67 years,
SD 9.5 years). 52.4% (n = 319) of trampoline users in this study
were female, 47.6% (n = 290) were male. In 11.1% (n = 71) of
the households, the trampoline was used by only one person,
in 47.4% of the households by two people, in 25.7% (n = 164)
by three people, and in 15.7% (n = 100) by four or more people.
86.7% (n = 548) of the respondents reported that several per-
sons use the trampoline simultaneously. Trampolines used
for multi-person trampolining featured a safety net more frequently (89.7%) compared with trampolines that were
reported to never see multi-person trampolining (79.9%) (p < 0.002).
Large trampolines (mean 396.8 cm, SD 87.6 cm) and trampolines used by older children (mean 15.1 years,
SD 7 years) were more likely to have no safety net (p < 0.001).
83.5% (n = 532) of respondents stated that an accident had
never occurred on their trampoline, 16.5% (n = 105) reported
that there had been a trampoline-related accident. The aver-
age age of a person involved in an accident was 13.5 years
(2–53 years, SD 4.7 years). In 33% of accidents, only one per-
son was on the trampoline, and in 67% two or more people
were. More accidents involved male (52.9%) than female
users (47.1%), with no statistically significant difference
between genders (p < 0.283).

A total of 99 injuries were reported. The injuries were divided
into five groups for evaluation: teeth, head, arms, legs, and
trunk. Dental injuries occurred in 23.2% (n = 23) of the acci-
cidents. Head injuries, such as concussions, lacerations, or inju-
ries to the eyes and lips, occurred in 21.2% (n = 21) of cases.
Arms and legs were fractured, sprained, or otherwise injured
in 25.3% (n = 25) of the accidents. The trunk was involved in
5.1% (n = 5). A physician or dentist was consulted in two-thirds
of the accidents.

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**Tab. I** List of questionnaire items with possible answers given in brackets where applicable

<table>
<thead>
<tr>
<th></th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What kind of trampoline do you own (onground, inground, I don‘t own a trampoline)?</td>
</tr>
<tr>
<td>2</td>
<td>Diameter of the bounce mat (cm)?</td>
</tr>
<tr>
<td>3</td>
<td>Safety net available (yes, no)?</td>
</tr>
<tr>
<td>4</td>
<td>Number of people who use the trampoline regularly (age, gender)?</td>
</tr>
<tr>
<td>5</td>
<td>Is the trampoline used by several people at the same time (yes, no)?</td>
</tr>
<tr>
<td>6</td>
<td>Has there ever been an accident on the trampoline (yes, no)?</td>
</tr>
<tr>
<td>7</td>
<td>Number of people on the trampoline at the time of the accident (alone, 2, 3, 4+)?</td>
</tr>
<tr>
<td>8</td>
<td>Type of injury (broken bone in face, broken arm, broken leg, spinal cord injury, injured lip)? (tooth hit, tooth piece broken, tooth displaced, whole tooth knocked out) (visited a doctor, visited a dentist)</td>
</tr>
<tr>
<td>9</td>
<td>Age and gender of the person involved in the accident (m, f)?</td>
</tr>
<tr>
<td>10</td>
<td>Dental accident (teeth hit on own knee, teeth hit on the head of another trampoline user, teeth struck on the edge of the trampoline, fell off the trampoline)</td>
</tr>
<tr>
<td>11</td>
<td>Do you have any comments or additions?</td>
</tr>
</tbody>
</table>

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**Fig. 2** Left: inground trampoline, featuring a bounce mat that is level with the ground, without safety net; right: onground trampoline, featuring a bounce mat located above ground level, with safety net.
According to the present study, a trampoline-related accident occurred in 16.5% of the households with a garden trampoline. Compared with other high-risk leisure activities and sports, such as riding a kick scooter (29.1%) or mountain biking (53.1%), trampoline use entailed fewer risks of sustaining injuries (Baußmann et al. 2012; Müller et al. 2008). However, owing to the close-ended questions used in present study, no minor accidents were reported by respondents. If minor accidents had been included, the accident frequency might have been higher.

A dental accident occurred on 3.6% of the total 637 trampolines assessed in the present study. This rate is lower compared with mountain biking (5.7%), but higher than for kick scooter riding (3.1%) or skiing (2.2%) (Müller et al. 2008; Baußmann et al. 2012; Innerhofer et al. 2013). As in mountain biking and kick scooter riding, tooth fractures occurred most frequently in trampolining. An investigation into the causes of general injuries, such as bruises, sprains, and fractures sustained while using a trampoline, revealed that most injuries occurred owing to incorrect landing on the bouncing mat (42%). Falling off the trampoline (27%) was ranked second among the causes of accidents, followed by injuries that occurred on the trampoline frame (19%) or resulted from colliding with another trampoline user (10%). Dental injuries were listed among accidents frequently caused by the trampoline frame (Alexander et al. 2010). In accordance with previous studies, 86.7% of respondents in the present study reported that their trampoline was regularly used by more than one person at a time (Shields et al. 2005). The results of the present survey indicate a 3.6-fold increase in the likelihood of trampoline-related dental injuries when the trampoline is used by two or more persons simultaneously. Moreover, the results of the present study suggest that the diameter of the bounce mat has a significant impact on the frequency of trampoline related accidents. This may be due to the fact that bigger bounce mats facilitate higher jumps, which, in turn, involve a heightened risk for injury. In addition, multi-person trampolining is easier on bigger sized bounce mats and multi-person use is considered an important risk factor for trampoline-related accidents. It is therefore important to increase parental and public awareness regarding the potential dangers of multi-person trampolining regardless of trampoline size.

Compared with other studies, the victims of trampoline-related accidents tended to be older according to the present study (Thi Huynh et al. 2018; Woodward et al. 1992; Choi et al. 2018). However, most of the other studies’ data were collected in hospitals, where bone fractures were particularly prominent. Yet, fractures are more common in children younger than 6 years (Klimek et al. 2013; Choi et al. 2018). In particular, when the trampoline is used by more than one person at a time, larger and heavier children may generate more recoil from the jumping surface. This recoil can cause significant injury to a young child (Woodward et al. 1992).

The present study revealed that the presence of a safety net had no statistical effect on the occurrence of trampoline related accidents. This finding is in line with data reported in a previous study, which showed that bone fractures occur more frequently on trampolines with a safety net (Klimek et al. 2013). Presumably, safety nets may encourage trampoline user to make more daring and risky jumps.

The present study has some limitations that require careful consideration. The study was subject to the inherent method-
Einleitung


Material und Methoden

Die Datenerhebung erfolgte durch die Auswertung von Luftaufnahmen und das Versenden standardisierter Fragebögen. Von 1212 versendeten Fragebögen konnten 637 in die Studie eingeschlossen werden. Die Daten wurden in Bezug auf Unfallart, Material und Methoden

resultate

Insgesamt ereigneten sich 105 Trampolinunfälle (16,5%), davon 23 Zahnverletzungen (23,2%), 39,1% (n = 9) waren Zahnfrakturen, 30,4% (n = 7) Konkussionen, 17,4% (n = 4) Avulsionen und 13,0% (n = 3) Dislokationsverletzungen. Die Zähne wurden überwiegend am Trampolinrahmen (26,2%, n = 6) oder am eigenen Knie (26%, n = 6) angeschlagen. Zahnunfälle ereigneten sich 3,6-mal häufiger, wenn das Trampolin von mehreren Personen gleichzeitig benutzt wurde. Auf Inground-Trampolinen ereigneten sich 2,4-mal häufiger Zahnunfälle als auf Onground-Trampolinen. Statistisch hatte lediglich der Durchmesser des Trampolins Einfluss auf die Häufigkeit der Unfälle: Grössere Trampoline führten häufiger zu Unfällen.

Discussion

References


swisstopo.admin.ch

