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Dental Injuries on Garden Trampolines

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Sport equipment
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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 (BENO 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 (MEYERBER 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 (AWH) 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-built tool of map.search.ch and stored in a purpose-built, secured 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 let-



Fig. 1 Garden trampoline as seen on map.search.ch

Tab.1 List of questionnaire items with possible answers given in brackets where applicable

1	What kind of trampoline do you own (onground, inground, I don't own a trampoline)?
2	Diameter of the bounce mat (cm)?
3	Safety net available (yes, no)?
4	Number of people who use the trampoline regularly (age, gender)?
5	Is the trampoline used by several people at the same time (yes, no)?
6	Has there ever been an accident on the trampoline (yes, no)?
7	Number of people on the trampoline at the time of the accident (alone, 2, 3, 4+)?
8	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)
9	Age and gender of the person involved in the accident (m, f)?
10	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)?
11	Do you have any comments or additions?

ter, outlining the aim of the study and the irreversibly anonymized 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 questionnaire 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 spreadsheet. Descriptive analysis included number of cases and percentages for categorical parameters (e.g., safety net). For continuous 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 accidents, 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

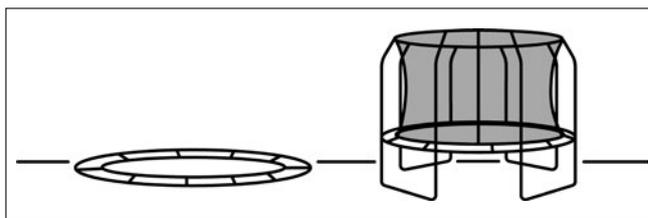


Fig. 2 Left: inground trampoline, featuring a bounce mat that is level with the ground, without safety net; right: onground trampoline, featuring a bounce mat located above ground level, with safety net.

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 error for multiple comparisons. All analyses were carried out with the statistical program R version 3.5.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Of the 1212 letters sent out, the post office returned six undelivered 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 trampoline 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 persons 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 average 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 person 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 accidents. Head injuries, such as concussions, lacerations, or injuries 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.

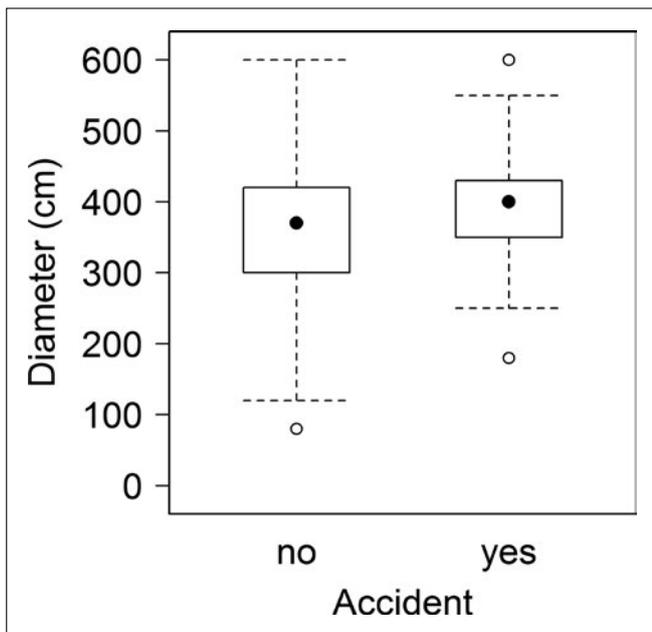


Fig. 3 Boxplot of accident frequency in relation to trampoline diameter

Of the 23 dental accidents, 9 were dental fractures, 7 were concussions, 4 were avulsions, and 3 were dislocation injuries. In these cases, the teeth were struck on the person's own knee ($n=6$), on the trampoline itself ($n=6$), on the head of another trampoline user ($n=5$), or there was a fall from the trampoline ($n=1$). In five cases, no details on the circumstances of the accident were provided.

Dental accidents occurred 3.6 times more frequently (95% CI: 0.5.27) when the trampoline was used by several persons at the same time. Dental accidents were 2.4 times more frequent on inground trampolines (95% CI: 0.5.11) than on onground trampolines.

For the occurrence of accidents in general, the diameter of the trampoline had the greatest influence ($p=0.044$). Trampolines on which an accident occurred were, on average, 20 cm larger compared with trampolines on which no accident took place (Fig. 3). Neither the presence of a safety net, nor the type of trampoline, nor the number of people on the trampoline, nor the age and gender of the trampoline users had a significant influence on the frequency of accidents ($p \geq 0.084$).

Discussion

The study showed, based on survey data of 637 Swiss households with a garden trampoline, that the diameter of a trampoline's bounce mat had a significant impact on the frequency of trampoline-related accidents. More accidents happened on trampolines with a larger bounce mat. Consequently, the null hypothesis had to be rejected. Dental injuries – tooth fractures, concussions and dislocation injuries showing comparable rates – were sustained in 23.2% of the accidents. The present study, therefore, suggests that concerted efforts are needed to reduce the frequency and severity of trampoline-related accidents.

A retrospective study reported that in a British hospital 11.1% of all fractures in children who had to be treated under general anesthesia were due to trampoline accidents. This was about the same as for soccer accidents and higher than for bicycling, skating, horseback riding, or climbing (BHANGAL ET AL. 2006).

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 (BAUMGARTNER 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; BAUMGARTNER 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-

ological and reporting limitations of questionnaire-based surveys. Considering the voluntary nature of the survey, the response rate of 60.2% was high, which may be indicative of trampoline owners' interest in trampoline-related accidents. Nevertheless, the potential of response and participation biases ought to be taken into account. A random selection of Swiss households with a garden trampoline was made to reduce the risk of selection bias. Though no data on the service time of a respondent's trampoline were gathered, the random selection of households with garden trampolines ensured that the average service time of trampolines included in the study was close to the factual average across Switzerland. It is, however, crucial to take account of the fact that only trampolines located in gardens of private residences were eligible for inclusion. Trampolines belonging to apartment buildings were excluded in the present study because it was unfeasible to identify persons who regularly used such trampolines. Consequently, the sample of the study is biased towards persons and families living in detached houses and it is conceivable that, say, multi-person trampoline use is more frequent on trampolines belonging to apartment buildings.

Zusammenfassung

Einleitung

Gartentrampoline erfreuen sich in der Schweiz grosser Beliebtheit. Die meisten Unfälle führen zu Frakturen und Weichteilverletzungen der Extremitäten. Während diese Verletzungsarten in zahlreichen Studien bereits gut untersucht wurden, gab es über Zahnverletzungen auf Trampolinen bisher noch keine Studie. Ziel der vorliegenden Arbeit war die Untersuchung von Zahnunfällen auf Gartentrampolinen in der Schweiz sowie die Analyse möglicher Einflussfaktoren.

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 Unfall, Art des Trampolins (inground oder onground) und das Vorhandensein eines Fangnetzes ausgewertet.

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) Avulsions- 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.

Diskussion

Die vorliegende Studie zeigt, dass das Trampolinspringen wie das Kickscooter-Fahren oder das Skifahren ein Risiko für Zahnverletzungen darstellt. Daher sollten Eltern und Trampolinspringer/innen auch über die erhöhte Gefahr von Zahnunfällen in Kenntnis gesetzt werden.

Résumé

Introduction

Les trampolines de jardin sont très populaires en Suisse. La plupart des accidents entraînent des fractures et des lésions des tissus mous aux extrémités. Bien que ces types de blessures aient déjà été bien étudiés dans de nombreuses études, aucune étude n'a jusqu'à présent été menée sur les blessures aux dents sur les trampolines. Le but de ce travail était d'étudier les accidents dentaires sur les trampolines de jardin en Suisse et d'analyser les éventuels facteurs d'influence.

Matériel et méthodes

Les données ont été collectées en évaluant des photographies aériennes et en envoyant des questionnaires standardisés. Sur 1212 questionnaires envoyés, 637 ont pu être inclus dans l'étude. Les données ont été évaluées en fonction de l'accident, du type de trampoline (inground ou onground) et de la disponibilité d'un filet de sécurité.

Résultats

Au total, 105 accidents de trampoline (16,5%) se sont produits, dont 23 étaient des blessures aux dents (23,2%). 39,1% (n = 9) étaient des fractures dentaires, 30,4% (n = 7) des contusions, 17,4% (n = 4) des avulsions et 13,0% (n = 3) des luxations. La plupart des dents étaient ébréchées sur le cadre du trampoline (26,2%, n = 6) ou sur le propre genou de l'athlète (26%, n = 6). Les accidents dentaires étaient 3,6 fois plus fréquents lorsque le trampoline était utilisé par plusieurs personnes en même temps. Les accidents dentaires sont survenus 2,4 fois plus souvent sur les trampolines creusés que sur les trampolines terrestres. Statistiquement, seul le diamètre du trampoline a une influence sur la fréquence des accidents: les trampolines plus grands entraînent plus d'accidents.

Discussion

La présente étude montre que sauter sur un trampoline présente un risque de blessures dentaires comme c'est le cas avec le kick scooter ou le ski. Par conséquent, les parents et les sauveurs de trampoline devraient également être informés du risque accru d'accidents dentaires.

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