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# Evaluation of Injuries in Cheerleaders in Singapore

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## Overview of Cheerleading

### (A) Cheerleading Positions

#### 1. Flyer

The flyer is the athlete being supported above the performance surface in a stunt, pyramid or toss.

#### 2. Base

A base is the person in direct weight-bearing contact with the performance surface providing support for others.

- **Main Base**

The main base has the majority of the flyer's foot and the majority of her weight. He/she will be almost directly under the stunt until it is cradled or brought down.

- **Secondary base/Side base**

The secondary base helps lift the flyer up into the air and support the flyer's foot.

#### 3. Spotter

The spotter is responsible for preventing injuries by protecting the head and shoulders of a flyer during a stunt, pyramid or toss.


**Figure 1:** Cheerleading stunt basic positions

#### 4. Prep position

This is the preparation before a stunt, in which the lowest connection between the base(s) and the flyer is at shoulder level.

**Figure 2:** Cheerleading prep position

#### 5. Cradle position

The position at the end of a stunt, where bases support the flyer by wrapping their arms under the back and legs of the flyer. The flyer lands in a pike position below prep level.

**Figure 3:** Cheerleading cradle position

## (B) Cheerleading Stunts

### 1. Toss

An airborne stunt where base(s) execute a throwing motion initiated from waist level to increase the height of the flyer. The top person becomes free from all contact of bases or other flyers. A basket toss is a toss involving 2 or 3 bases and a spotter. 2 of the bases use their hands to interlock wrists. In this toss, the flyer is thrown into the air from a set position. She then extends her arms to reach for the maximum height possible before hitting a pose or hand position, then lands in a cradle position.

**Figure 4:** Cheerleading basket toss

### 2. Partner stunt/release move

In a partner stunt, the base and flyer become free of contact with each other, and the flyer comes back to the same base.

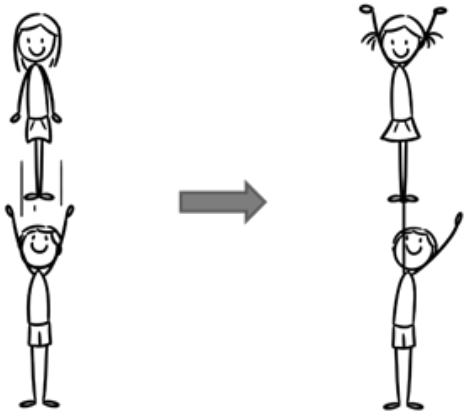

**Figure 5:** Cheerleading partner stunt

### 3. Jumps

A jump is an airborne position not involving hip-over-head rotation created by using one's own feet and lower body power to push off the performance surface.

A jump skill is a skill that involves a change in body position during a jump (e.g. toe touch, pike).

**Figure 6:** Cheerleading jumps

### 4. Standing Tumbling

This is a tumbling skill performed from a standing position without any previous forward momentum.

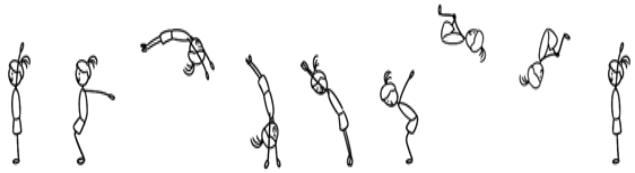

**Figure 7:** Cheerleading standing tumbling

### 5. Running Tumbling

This is a tumbling skill that involves a forward step or a hurdle used to gain momentum as an entry to a tumbling skill.

**Figure 8:** Cheerleading running tumbling

### 6. Pyramid

A pyramid consists of 2 or more connected stunts.

Pyramid heights are measured in body lengths. In a 2½ pyramid, the flyer(s) has weight bearing support by at least one other flyer, and is free of contact from the base(s).

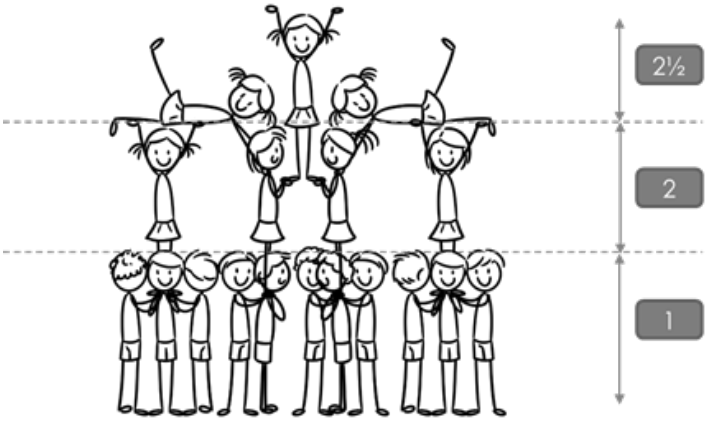


**Figure 9:** Cheerleading pyramid

### (C) Cheerleading Coaching Qualifications

#### 1. International Federation of Cheerleading (IFC)

The IFC is a non-profit federation based in Tokyo, Japan, formed in 1998. The IFC is an Associate Member of the World Dance Sport Federation (WDSF) which is recognised by the International Olympic Committee (IOC).

The IFC sponsors a variety of international cheerleading competitions, including the Cheerleading World Championships.

#### 2. The American Association of Cheerleading Coaches and Administrators (AACCA)

The AACCA was founded in 1987. The association conducts cheerleading safety education and risk management courses. The National Federation of High Schools (NFHS) Coach Certification Program is a national professional credential under the AACCA that for individuals who are currently coaching at the interscholastic level.

## Introduction to Our Study

From 1990 to 2003, the number of US cheerleaders 6 years and older increased by approximately 600 000 from 3.0 to 3.6 million [1]. Girls represent the majority (96%) of participants [2]. Cheerleading injuries in the United States have been increasing steadily over the past few decades. The US Consumer Product Safety Commission reported 4954 hospital emergency department visits for cheerleading injuries in 1980. By 2007, the Consumer Product Safety Commission reported this number had climbed more than 400% to 26 786 [3]. The number of catastrophic injuries related to cheerleading has increased from 1.5 per year from 1982 to 1992 to 4.8 per year from 2003 to 2009 [4]. One study reports that cheerleading had the highest average number of days lost per injury, followed by girls' basketball, wrestling, boys' cross-country, and girls' tennis.

Risk factors for cheerleading injuries include higher BMI, previous injury, cheering on harder surfaces, performing stunts, and supervision by a coach with low level of training and experience [5, 6]. One study of 9022 US cheerleaders from 412 teams was performed in 2009, which evaluated injuries sustained by cheerleaders in the US [7]. Till date, no similar studies have been conducted to evaluate the rate, types and mechanisms involved in injuries sustained by the varsity cheerleading population in Singapore.

In the paper, we studied our local varsity cheerleading population and collated the incidence of cheerleading injuries, to derive methods aimed at decreasing the number and severity of injuries amongst varsity cheerleaders in Singapore.

## Methodology

### (A) Participants

Cheerleaders across polytechnic, university, and open teams who participated in the 2017 National Cheerleading Championships in Singapore

### (B) Inclusion Criteria

- 18 years of age and older at time of commencement of study
- Have spent at least 12 consecutive months training with a varsity or open-category cheerleading team

### (C) Exclusion Criteria

- Aged below 18 years at time of commencement of study
- Non-members of competitive cheerleading teams
- Cheerleaders with less than 12 consecutive months of training with a varsity or open-category cheerleading team

### (D) Data Collection

Data was gathered via an online questionnaire. Demographic information on gender, current age, BMI, previous injuries, years of cheerleading experience was collected. Details on the number of cheerleading practices per week, length of practice sessions, as well as maximum height of pyramids were also collated.

Study participants were asked if they had ever been injured during cheer training, performances or competitions. Injury was defined as any physical insult that resulted in absence from one or more training, performance or competition days, and was profiled by body parts affected, as well as severity of injury. Severity was classified as minor (1-7 days of training, performance or competition days missed), moderate (8-21 days), severe (more than 21 days), or activity-ending [8]. Information on circumstances of the injury (practice/competition, indoors/outdoors, supervised/unsupervised) was also recorded.

Specific questions pertaining to the mechanism of injury, such as questions on the stunt performed, the place of injury, the cheerleading surface, and the use of spotters were also evaluated. Where medical attention was sought, the medical diagnosis, treatment and outcome of the patient were also noted. In addition, we collated the number of years of coaching education each team's coach possessed, as well as his/her necessary qualifications.

### (E) Statistical Analysis

Statistical analysis was performed using SPSS Statistics version 25 (IBM Corp, Armonk, US). Pearson chi-square test was used to test associations for categorical variables; and either the Mann-Whitney U test or the Student t-test was used to analyse continuous variables, depending on normality. P values of $<0.05$ were considered to be statistically significant. Variables that had statistical significance at the univariable analysis were entered into the multivariable analysis.

## Results

### (A) Participant Demographics

A total of 111 cheerleaders across 5 local cheerleading teams were recruited, of which 54 (48.6%) were female, and 57 (51.4%) were male. These consisted of 25 polytechnic category cheerleaders, 38 university cheerleaders, 36 open-category cheerleaders, and 12 national cheerleaders. The mean age group of all participants was 23.1.

| | Polytechnic | University | Open | National | Total |
|---|---|---|---|---|---|
| **Number of Cheerleaders (n)** | **25** | **38** | **36** | **12** | **111** |
| **Gender** | | | | | |
| Female | 14 (56.0) | 20 (52.6) | 15 (41.7) | 5 (41.7) | 54 (48.6) |
| Male | 11 (44.0) | 18 (47.4) | 21 (58.3) | 7 (58.3) | 57 (51.4) |
| **Age Group** | | | | | |
| Mean ± SD | 19.88±1.740 | 23.61±2.881 | 23.83±3.895 | 26.00±3.742 | 23.10±3.64 |
| Minimum | 18 | 19 | 18 | 21 | 18 |
| Median | 20.00 | 23.00 | 24.00 | 26.00 | 23.00 |
| Maximum | 24 | 30 | 32 | 31 | 32 |

The mean BMI of all participants was 23.3.

20 (18.0%) participants had 1 year of cheerleading experience, 29 (26.1%) had 2 years of experience, 13 (11.7%) had 3 years, 16 (14.4%) had 4 years, 16 (14.4%) had 5 years, and 17 (15.0%) had more than 5 years of experience.

| | Polytechnic | University | Open | National | Total |
|---|---|---|---|---|---|
| **Number of Cheerleaders (n)** | **25** | **38** | **36** | **12** | **111** |
| **BMI** | | | | | |
| Mean ± SD | 20.70±3.286 | 22.57±4.432 | 22.92±4.153 | 22.92±4.995 | 23.30±4.21 |
| Minimum | 17 | 17 | 17 | 18 | 17 |
| Median | 19.30 | 21.45 | 22.00 | 22.25 | 21.80 |
| Maximum | 30 | 32 | 32 | 31 | 32 |
| **Year of cheerleading experience** | | | | | |
| 1 year | 15 (60.0) | 3 (7.9) | 1 (2.8) | 1 (8.3) | 20 (18.0) |
| 2 years | 8 (32.0) | 14 (36.8) | 7 (19.4) | 0 | 29 (26.1) |
| 3 years | 1 (4.0) | 4 (10.5) | 7 (19.4) | 1 (8.3) | 13 (11.7) |
| 4 years | 1 (4.0) | 7 (18.4) | 5 (13.9) | 3 (25.0) | 16 (14.4) |
| 5 years | 0 | 3 (7.9) | 10 (27.8) | 3 (25.0) | 16 (14.4) |
| 6 years | 0 | 6 (15.6) | 6 (16.7) | 4 (33.3) | 16 (14.4) |
| 7 years | 0 | 1 (2.6) | 0 | 0 | 1 (0.6) |

### (B) Team Demographics

6 (5.4%) of cheerleaders surveyed competed in the girl's group category, while 105 (94.6%) competed in the mixed team category.

In terms of practice sessions, 9 (8.0%) cheerleaders reported having 1-2 practice sessions per week, and 102 (91.9%) reported having 3 or more practice sessions per week. 15 (13.5%) participants described practice sessions to last between 2-3 hours, while 96 (86.5%) cheerleaders reported practice sessions of more than 3 hours.

With regards to the height of pyramids, 80 (72.1%) participants described having pyramids up to a maximum height of 2½ persons, while 31 (27.9%) participants had teams with pyramids of maximum heights exceeding that of 2½ persons.

| | Polytechnic | University | Open | National | Total |
|---|---|---|---|---|---|
| **Number of Cheerleaders (n)** | **25** | **38** | **36** | **12** | **111** |
| **Group** | | | | | |
| Girls group | 0 | 0 | 6 (16.7) | 0 | 6 (5.4) |
| Mixed team | 25 (91.7) | 38 (100) | 30 (83.3) | 12 (100) | 105 (94.6) |
| **Number of practices per week** | | | | | |
| 1 | 0 | 0 | 1 (2.8) | 0 | 1 (0.9) |
| 2 | 3 (12.0) | 2 (5.3) | 2 (5.6) | 1 (8.3) | 8 (7.1) |
| 3 | 10 (40.0) | 16 (42.1) | 9 (25.0) | 5 (41.7%) | 40 (36.0) |
| >3 | 12 (48.0) | 20 (52.6) | 24 (66.7) | 6 (50.0) | 62 (55.9) |
| **Length of practice sessions** | | | | | |
| 2- 3 hours | 2 (8.0) | 11 (28.9) | 1 (2.8) | 1 (8.3) | 15 (13.5) |
| >3 hours | 23 (92.0) | 27 (71.1) | 35 (97.2) | 11 (91.7) | 96 (86.5) |
| **Maximum height of pyramids** | | | | | |
| 1½ | 1(4.0) | 1 (2.6) | 0 | 0 | 2 (1.8) |
| 2 | 4 (16.0) | 8 (21.0) | 3 (8.3) | 1 (8.3) | 16 (14.4) |
| 2½ | 15 (60.0) | 16 (42.1) | 24 (66.7) | 7 (58.3) | 62 (55.9) |
| >2½ | 5 (20.0) | 13 (34.2) | 9 (25.0) | 4 (33.3) | 31 (27.9) |

### (C) Injury Description

76 (68.5%) cheerleaders described having sustained injuries from cheerleading, while 35 (31.5%) participants had no previous cheerleading-related injuries. Of the 76 respondents with cheerleading-related injuries, 66 (86.8%) sustained their injuries during cheerleading practice, while 10 (13.2%) were injured during cheerleading competitions.

19 (26.8%) participants developed their injuries within the first 1 hour of practice/competition, 41(57.7%) were injured within the second hour, and 11 (15.5%) participants were injured after the second hour of the session.

61 (85.9%) respondents were injured in an indoor location, while the remaining 10 (14.1) sustained injuries in outdoor locations. 70 (98.6%) cheerleaders described their injuries to be on a mat, while 1 (1.4%) cheerleader was injured on an artificial turf.

| | Polytechnic | University | Open | National | Total |
|---|---|---|---|---|---|
| **Any previous injuries** | | | | | |
| **Number of Cheerleaders (n)** | **25** | **38** | **36** | **12** | **111** |
| Yes | 11 (44.0) | 33 (86.8) | 22 (61.1) | 10 (83.3) | 76 (68.5) |
| No | 14 (56.0) | 5 (13.2) | 14 (38.9) | 2 (16.7) | 35 (31.5) |
| **Type of event** | | | | | |
| **Number of Cheerleaders (n)** | **11** | **33** | **21** | **11** | **76** |
| Competition/Performance | 2 (18.2) | 5 (15.2) | 1 (4.8) | 2 (18.2) | 10 (13.2) |
| Practice | 9 (81.8) | 28 (84.8) | 20 (95.2) | 9 (81.8) | 66 (86.8) |
| **Time into practice session** | | | | | |
| **Number of Cheerleaders (n)** | **12** | **29** | **23** | **7** | **71** |
| Within first 30 min | 1 (8.3) | 3 (10.3) | 2 (8.7) | 0 | 6 (8.5) |
| 31 – 60 min | 3 (25.0) | 5 (17.2) | 4 (17.4) | 1 (14.3) | 13 (18.3) |
| 61 – 90 min | 3 (25.0) | 13 (44.8) | 8 (34.8) | 4 (57.1) | 28 (39.4) |
| 91 – 120 min | 3 (25.0) | 3 (10.3) | 5 (21.7) | 2 (28.6) | 13 (18.3) |
| >120 min | 2 (16.7) | 5 (17.2) | 4 (17.4) | 0 | 11 (15.5) |
| **Location** | | | | | |
| **Number of Cheerleaders (n)** | **12** | **29** | **23** | **7** | **71** |
| Indoor | 12 (100.0) | 24 (82.8) | 21 (91.3) | 4 (57.1) | 61 (85.9) |
| Outdoor | 0 | 5 (17.2) | 2 (8.7) | 3 (42.9) | 10 (14.1) |
| **Type of surface** | | | | | |
| **Number of Cheerleaders (n)** | **12** | **29** | **23** | **7** | **71** |
| Mat | 12 (100.0) | 29 (100.0) | 22 (95.7) | 7 (100.0) | 70 (98.6) |
| Artificial turf | 0 | 0 | 1 (4.3) | 0 | 1 (1.4) |

The most common mechanism of injury was from falling from a stunt (19 cheerleaders, 26.8%), followed by injuries sustained while tumbling (13 cheerleaders, 18.3%), and while basing, and from slipping/tripping/twisting a body part (11 cheerleaders each, 15.5%).

Injuries resulting from attempting pyramids were most reported (18 respondents, 31.6%). Other common manoeuvres which resulted in injuries were running tumbling (15 respondents, 26.3%), as well as partner stunts (13 respondents, 22.8%).

Most injuries were sustained while spotters were present (70 participants, 98.6%), and under the supervision of their respective coaches (68 participants, 89.5%).

| | Polytechnic | University | Open | National | Total |
|---|---|---|---|---|---|
| **Mechanism of injury** | | | | | |
| **Number of Cheerleaders (n)** | **12** | **29** | **23** | **7** | **71** |
| Basing | 2 (16.7) | 4 (13.8) | 4 (17.4) | 1 (14.3) | 11 (15.5) |
| Collision | 1 (8.3) | 1 (3.4) | 2 (8.7) | 2 (28.6) | 6 (8.5) |
| Falling to complete manoeuvre | 2 (16.7) | 2 (6.9) | 3 (13.0) | 2 (28.6) | 5 (7.0) |
| Fell from stunt | 0 | 8 (27.6) | 7 (30.4) | 0 | 19 (26.8) |
| Slipped/tripped/twisted body part | 0 | 1 (3.4) | 2 (8.7) | 0 | 3 (4.2) |
| Spotting | 1 (8.3) | 6 (20.7) | 3 (13.0) | 1 (14.3) | 11 (15.5) |
| While jumping | 1 (8.3) | 1 (3.4) | 1 (4.3) | 0 | 3 (4.2) |
| While tumbling | 5 (41.7) | 6 (20.7) | 1 (4.3) | 1 (14.3) | 13 (18.3) |
| **Manoeuvre attempted** | | | | | |
| **Number of Cheerleaders (n)** | **11** | **25** | **17** | **4** | **57** |
| Jumping | 2 (18.2) | 2 (8.0) | 0 | 0 | 4 (7.1) |
| Partner stunt | 2 (18.2) | 6 (24.0) | 3 (17.6) | 2 (50.0) | 13 (22.8) |
| Pyramid | 1 (9.1) | 6 (24.0) | 9 (52.9) | 2 (50.0) | 18 (31.6) |
| Running tumbling | 5 (45.5) | 8 (32.0) | 2 (11.8) | 0 | 15 (26.3) |
| Standing tumbling | 1 (9.1) | 3 (12.0) | 3 (17.6) | 0 | 7 (12.3) |
| **Spotter present** | | | | | |
| **Number of Cheerleaders (n)** | **12** | **29** | **23** | **7** | **71** |
| Yes | 12 (100.0) | 29 (100.0) | 22 (95.7) | 7 (100.0) | 70 (98.6) |
| No | 0 | 0 | 1 (4.3) | 0 | 1 (1.4) |
| **Supervision by coach** | | | | | |
| **Number of Cheerleaders (n)** | **4** | **32** | **32** | **8** | **76** |
| Yes | 3 (75.0) | 30 (93.8) | 28 (87.5) | 7 (87.5) | 68 (89.5) |
| No | 1 (25.0) | 2 (6.2) | 4 (12.5) | 1 (12.5) | 8 (10.5) |

### (D) Injuries Sustained

The most injured body part from our study was the ankle (25 cheerleaders, 36.8%), followed by the shoulder (16 cheerleaders, 23.5%), and the knee (13 cheerleaders, 19.1%).

43 (63.2%) respondents reported missing between 1-7 days of training due to their injuries, 11 (16.2%) respondents missed between 8-21 days of training, and 14 (20.6%) respondents missed more than 21 days of training owing to their injuries.

| | Polytechnic | University | Open | National | Total |
|---|---|---|---|---|---|
| **Number of Cheerleaders (n)** | **2** | **30** | **28** | **8** | **68** |
| **Body Part Injured** | | | | | |
| Ankle | 2 (100.0) | 10 (33.3) | 10 (35.7) | 3 (37.5) | 25 (36.8) |
| Cervical/thoracic spine | 0 | 4 (13.3) | 1 (3.6) | 0 | 5 (7.4) |
| Head injury | 0 | 2 (6.7) | 2 (7.1) | 4 (50.0) | 8 (11.8) |
| Lumbar spine | 0 | 0 | 1 (3.6) | 0 | 1 (1.5) |
| Knee | 0 | 8 (26.7) | 4 (14.3) | 1 (12.5) | 13 (19.1) |
| Shoulder | 0 | 6 (20.0) | 10 (35.7) | 0 | 16 (23.5) |
| **Number of training days missed due to injury** | | | | | |
| 1 – 7 days | 2 (100.0) | 15 (50.0) | 21 (75.0) | 5 (62.5) | 43 (63.2) |
| 8 - 21 days | 0 | 7 (23.3) | 3 (10.7) | 1 (12.5) | 11 (16.2) |
| > 21 days | 0 | 8 (26.7) | 4 (14.3) | 2 (25.0) | 14 (20.6) |

### (E) Medical Treatment

Of all the participants with previous cheerleading-related injuries, 42 (61.8%) sought medical attention. Amongst those who sought medical attention, most injuries (15 cheerleaders, 57.7%) were sprains/tears. 5 (19.2%) cheerleaders had lacerations, 3 (11.5%) cheerleaders sustained fractures, and 3 (11.5%) had concussions. The majority of cheerleaders (17 respondents, 65.4%) reported not having any long-term sequelae related to their injury.

| | Polytechnic | University | Open | National | Total |
|---|---|---|---|---|---|
| **Was medical attention sought** | | | | | |
| **Number of Cheerleaders (n)** | **2** | **30** | **28** | **8** | **68** |
| Yes | 7 (25.0) | 1 (50.0) | 14 (46.7) | 4 (50.0) | 26 (38.2) |
| No | 21 (75.0) | 1 (50.0) | 16 (53.3) | 4 (50.0) | 42 (61.8) |
| **What was the diagnosis** | | | | | |
| **Number of Cheerleaders (n)** | **7** | **1** | **14** | **4** | **26** |
| Sprain/tear | 6 (85.7) | 0 | 9 (64.3) | 0 | 15 (57.7) |
| Fracture | 0 | 0 | 3 (21.4) | 0 | 3 (11.5) |
| Laceration | 1 (14.3) | 0 | 1 (7.1) | 3 (75.0) | 5 (19.2) |
| Concussion | 0 | 1 (100.0) | 1 (7.1) | 1 (25.0) | 3 (11.5) |
| **Any long-term sequelae** | | | | | |
| **Number of Cheerleaders (n)** | **7** | **1** | **14** | **4** | **26** |
| Yes | 2 (28.6) | 0 | 6 (42.9) | 1 (25.0) | 9 (34.6) |
| No | 5 (71.4) | 1 (100.0) | 8 (57.1) | 3 (75.0) | 17 (65.4) |

### (F) Coach Demographics

28 (25.2%) of participants had cheerleading coaches between 20-23 years of age, 33 (29.7%) were coached by someone between 24-26 years of age, 24 (21.6%) had coaches between 27-30 years of age, and 26 (23.4%) had coaches above 30 years of age. 69 (62.2%) of participants had female coaches, while 43 (37.8%) had male coaches.

Amongst all participants, 27 (24.3%) were coached by someone with between 1-3 years of coaching experience, 46 (41.4%) had coaches with 4-5 years of experience, and 38 (34.2%) had coaches with more than 5 years of experience. With regards to coaching certification, 60 (54.1%) participants had coaches who were certified by the International Federation of Cheerleading (IFC), while 51 (45.9%) participants had coaches certified by the American Association of Cheerleading Coaches and Administrators (AACCA).

| | Polytechnic | University | Open | National | Total |
|---|---|---|---|---|---|
| **Number of Cheerleaders (n)** | **25** | **38** | **36** | **12** | **111** |
| **Age of coach** | | | | | |
| | | | | | |
| 20- 23 | 2 (8.0) | 7 (18.4) | 18 (50.0) | 1 (8.3) | 28 (25.2) |
| 24-26 | 21 (84.0) | 6 (15.8) | 4 (11.2) | 2 (16.7) | 33 (29.7) |
| 27-30 | 2 (8.0) | 2 (5.3) | 12 (33.4) | 8 (66.7) | 24 (21.6) |
| >30 | 0 | 23 (60.5) | 2 (5.2) | 1 (8.3) | 26 (23.4) |
| **Years as cheerleading coach** | | | | | |
| 1 | 0 | 2 (5.3) | 8 (22.2) | 0 | 10 (9.0) |
| 2 | 0 | 1 (2.6) | 9 (25.0) | 0 | 10 (9.0) |
| 3 | 1 (4.0) | 1 (2.6) | 5 (13.9) | 0 | 7 (6.3) |
| 4 | 4 (16.0) | 4 (10.5) | 7 (19.4) | 3 (25.0) | 18 (16.2) |
| 5 | 1 (4.0) | 20 (52.6) | 3 (8.3) | 4 (33.3)) | 28 (25.2) |
| 6 | 6 (24.0) | 10 926.3) | 1 (2.8) | 3 (25.0) | 10 (9.0) |
| 7 | 13 (52.0) | 2 (18.7) | 3 (8.3) | 2 (16.7) | 28 (25.2) |
| **Gender of coach** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Female | 0 | 8 (21.1) | 28 (77.8) | 8 (66.7) | 69 (62.2) |
| Male | 25 (100) | 30 (78.9) | 8 (22.2) | 4 (33.3) | 43 (37.8) |
| **Coaching Certification** | | | | | |
| IFC | 14 (56.0) | 22 (57.9) | 24 (66.7) | 12 (100.0) | 60 (54.1) |
| AACCA/NFHS | 11 (44.0) | 16 (42.1) | 12 (33.3) | 0 | 51 (45.9) |

### (G) Time into Practice Session vs Mechanism of Injury

There was a significant association between injuries sustained while jumping, and an early time into the practice session (within the first 30min, and from 31-60min, p=0.045). A higher proportion of cheerleaders fell from stunts at 61-90min and 91-120min into the practice session (p=0.010).

| | Total (n = 76) | Time into Practice Session | | | | | p-value |
|---|---|---|---|---|---|---|---|
| | | First 30 mins | 31–60min | 61–90min | 91–120min | >120min | |
| **While Tumbling** | 14 (18.4%) | 0 (0%) | 4 (30.8%) | 3 (10.3%) | 4 (28.6%) | 3 (25%) | 0.212 |
| **While Jumping** | 3 (3.9%) | 1 (12.5%) | 2 (15.4%) | 0 (0%) | 0 (0%) | 0 (0%) | **0.045** |
| **Spotting** | 3 (3.9%) | 0 (0%) | 0 (0%) | 1 (3.4%) | 0 (0%) | 2 (16.7%) | 0.238 |
| **Slipped / tripped / twisted body part** | 11 (14.5%) | 2 (25%) | 4 (30.8%) | 3 (10.3%) | 1 (7.1%) | 1 (8.3%) | 0.308 |
| **Fell From Stunt** | 22 (28.9%) | 3 (37.5%) | 0 (0%) | 12 (41.4%) | 6 (42.9%) | 1 (8.3%) | **0.010** |
| **Failing to Complete Manoeuvre** | 6 (7.9%) | 1 (12.5%) | 1 (7.7%) | 3 (10.3%) | 1 (7.1%) | 0 (0%) | 0.905 |
| **Collision** | 5 (6.6%) | 0 (0%) | 0 (0%) | 3 (10.3%) | 1 (7.1%) | 1 (8.3%) | 0.916 |
| **Basing** | 12 (15.8%) | 1 (12.5%) | 2 (15.4%) | 4 (13.8%) | 1 (7.1%) | 4 (33.3%) | 0.518 |

### (H) Gender vs Mechanism of Injury

Males were significantly more likely to be injured while tumbling (p=0.018) and while basing (p=0.025) as compared to females. Females were more likely to have fallen from stunts (p=<0.001) as compared to males.

| | Female (n = 38) | Male (n = 38) | p-value |
|---|---|---|---|
| **While Tumbling** | 3 (7.9%) | 11 (28.9%) | **0.018** |
| **While Jumping** | 2 (5.3%) | 1 (2.6%) | > 0.999 |
| **Spotting** | 0 (0.0%) | 3 (7.9%) | 0.240 |
| **Slipped / tripped / twisted body part** | 7 (18.4%) | 4 (10.5%) | 0.328 |
| **Fell From Stunt** | 21 (55.3%) | 1 (2.6%) | **< 0.001** |
| **Falling Complete Manoeuvre** | 3 (7.9%) | 3 (7.9%) | > 0.999 |
| **Collision** | 0 (0.0%) | 5 (13.2%) | 0.054 |
| **Basing** | 2 (5.3%) | 10 (26.3%) | **0.025** |

### (I) Gender vs Body Part Injured

There were no significant associations between gender and body part injured.

| | Female (n = 38) | Male (n = 38) | p-value |
|---|---|---|---|
| **Shoulder** | 10 (26.3%) | 9 (23.7%) | 0.791 |
| **Lumbar spine** | 1 (2.6%) | 0 (0.0%) | > 0.999 |
| **Knee** | 9 (23.7%) | 9 (23.7%) | > 0.999 |
| **Head injury** | 4 (10.5%) | 8 (21.1%) | 0.346 |
| **Cervical/thoracic spine** | 2 (5.3%) | 0 (0.0%) | 0.493 |
| **Ankle** | 12 (31.6%) | 12 (31.6%) | > 0.999 |

### (J) BMI vs Mechanism of Injury

The BMI was significantly smaller for cheerleaders who suffered injuries resulting from falls from stunts compared to those who did

not (p = 0.001).

On the other hand, cheerleaders who suffered basing and collision injuries had significantly larger BMIs (p=0.015 for basing injuries, p=0.029 for collision injuries).

| Mechanism of injury | BMI of injured respondents | BMI of Non-injured respondents | p-value |
|---|---|---|---|
| **While Tumbling** | 22.4 (19.1-25.4) | 21.4 (18.4-24.1) | 0.551 |
| **While Jumping** | 19.3 (17.9-29.1) | 21.6 (18.4-24.2) | 0.841 |
| **Spotting** | 24.2 (21.1-32.1) | 21.1 (18.4-24.5) | 0.142 |
| **Slipped / tripped / twisted body part** | 22.3 (17.8-22.9) | 21.1 (18.6-24.3) | 0.460 |
| **Fell from Stunt** | 19.1 (18.3-20.8) | 23.0 (19.5-26.4) | **0.001** |
| **Failing to Complete Manoeuvre** | 20.8 (18.0-25.3) | 21.5 (18.4-24.2) | 0.773 |
| **Collision** | 26.2 (22.9-28.2) | 21.0 (18.4-24.1) | **0.029** |
| **Basing** | 24.2 (22.6-28.5) | 20.9 (18.3-23.9) | **0.015** |

### (K) BMI vs Body Part Injured

Most injuries sustained in pyramids were a result of falling from stunts (p=<0.001), as opposed to basing or spotting.

| Body part injured | BMI of injured respondents | BMI of Non-injured respondents | p-value |
|---|---|---|---|
| **Shoulder** | 19.9 (18.2-23.8) | 21.9 (18.6-24.5) | 0.240 |
| **Lumbar spine** | 19.8 (n = 1) | 21.6 (18.4-24.2) | 0.816 |
| **Knee** | 20.5 (18.0-24.4) | 21.7 (18.9-24.1) | 0.521 |
| **Head injury** | 23.3 (19.0-26.5) | 21.1 (18.4-24.2) | 0.248 |
| **Cervical/thoracic spine** | 19.3 (17.5-21.1) | 21.7 (18.4-24.2) | 0.281 |
| **Ankle** | 22.0 (19.3-26.4) | 20.9 (18.3-24.2) | 0.209 |

### (L) Mechanism of Injury in Pyramids

Most injuries sustained in pyramids were a result of falling from stunts (p=<0.001), as opposed to basing or spotting.

| | Sustained injuries from pyramids (n = 21) | No injuries sustained from pyramids (n = 55) | p-value |
|---|---|---|---|
| **Spotting** | 1 (4.8%) | 2 (3.6%) | > 0.999 |
| **Fell From Stunt** | 14 (66.7%) | 8 (14.5%) | **< 0.001** |
| **Failing to Complete Manoeuvre** | 1 (4.8%) | 5 (9.1%) | > 0.999 |
| **Collision** | 0 (0.0%) | 5 (9.1%) | 0.314 |
| **Basing** | 3 (14.3%) | 9 (16.4%) | > 0.999 |

### (M) Manoeuvre Attempted vs Body Part Injured

There were no significant associations between manoeuvre attempted and body part injured.

| Manoeuvre Attempted | Any injury sustained from manoeuvre | | |
|---|---|---|---|
| **Toss** | **Yes (n = 12)** | **No (n = 64)** | **p-value** |
| Head injury | 3 (25.0%) | 9 (14.1%) | 0.390 |
| Cervical/thoracic spine | 0 (0.0%) | 2 (3.1%) | > 0.999 |
| Shoulder | 2 (16.7%) | 17 (26.6%) | 0.719 |
| Lumbar spine | 0 (0.0%) | 1 (1.6%) | > 0.999 |
| Knee | 2 (16.7%) | 16 (25.0%) | 0.720 |
| Ankle | 5 (41.7%) | 19 (29.7%) | 0.502 |
| **Standing Tumbling** | **Yes (n = 8)** | **No (n = 68)** | **p-value** |
| Head injury | 0 (0.0%) | 12 (17.6%) | 0.342 |
| Cervical/thoracic spine | 0 (0.0%) | 2 (2.9%) | > 0.999 |
| Shoulder | 4 (50.0%) | 15 (22.1%) | 0.102 |
| Lumbar spine | 0 (0.0%) | 1 (1.5%) | > 0.999 |
| Knee | 2 (25.0%) | 16 (23.5%) | > 0.999 |
| Ankle | 2 (25.0%) | 22 (32.4%) | > 0.999 |
| **Running Tumbling** | **Yes (n = 17)** | **No (n = 59)** | **p-value** |
| Head injury | 4 (23.5%) | 8 (13.6%) | 0.449 |
| Cervical/thoracic spine | 0 (0.0%) | 2 (3.4%) | > 0.999 |
| Shoulder | 4 (23.5%) | 15 (25.4%) | > 0.999 |
| Lumbar spine | 0 (0.0%) | 1 (1.7%) | > 0.999 |
| Knee | 3 (17.6%) | 15 (25.4%) | 0.747 |
| Ankle | 6 (35.3%) | 18 (30.5%) | 0.771 |
| **Pyramid** | **Yes (n = 21)** | **No (n = 55)** | **p-value** |
| Head injury | 4 (19.0%) | 8 (14.5%) | 0.727 |
| Cervical/thoracic spine | 1 (4.8%) | 1 (1.8%) | 0.479 |
| Shoulder | 5 (23.8%) | 14 (25.5%) | > 0.999 |
| Lumbar spine | 1 (4.8%) | 0 (0.0%) | 0.276 |
| Knee | 6 (28.6%) | 12 (21.8%) | 0.556 |
| Ankle | 4 (19.0%) | 20 (36.4%) | 0.177 |
| **Partner Stunt** | **Yes (n = 21)** | **No (n = 55)** | **p-value** |
| Head injury | 1 (6.7%) | 11 (18.0%) | 0.440 |
| Cervical/thoracic spine | 1 (6.7%) | 1 (1.6%) | 0.358 |
| Shoulder | 3 (20.0%) | 16 (26.2%) | 0.748 |
| Lumbar spine | 0 (0.0%) | 1 (1.6%) | > 0.999 |
| Knee | 4 (26.7%) | 14 (23.0%) | 0.744 |
| Ankle | 6 (40.0%) | 18 (29.5%) | 0.537 |
| **Jumping** | **Yes (n = 3)** | **No (n = 73)** | **p-value** |
| Head injury | 0 (0.0%) | 12 (16.4%) | > 0.999 |
| Cervical/thoracic spine | 0 (0.0%) | 2 (2.7%) | > 0.999 |
| Shoulder | 1 (33.3%) | 18 (24.7%) | > 0.999 |
| Lumbar spine | 0 (0.0%) | 1 (1.4%) | > 0.999 |
| Knee | 1 (33.3%) | 17 (23.3%) | 0.561 |
| Ankle | 1 (33.3%) | 23 (31.5%) | > 0.999 |

### (N) Coach's Qualification vs Mechanism of Injury

There were no significant associations between the type of qualification held by the coach and the mechanism of injury.

| | AACCA/NFHS (n = 34) | IFC (n = 42) | p-value |
|---|---|---|---|
| **While Tumbling** | 7 (20.6%) | 7 (16.7%) | 0.661 |
| **While Jumping** | 2 (5.9%) | 1 (2.4%) | 0.584 |
| **Spotting** | 1 (2.9%) | 2 (4.8%) | > 0.999 |
| **Slipped / tripped / twisted body part** | 7 (20.6%) | 4 (9.5%) | 0.204 |
| **Fell From Stunt** | 11 (32.4%) | 11 (26.2%) | 0.556 |
| **Falling Complete Manoeuvre** | 2 (5.9%) | 4 (9.5%) | 0.686 |
| **Collision** | 1 (2.9%) | 4 (9.5%) | 0.373 |
| **Basing** | 3 (8.8%) | 9 (21.4%) | 0.207 |

## Discussion

### (A) Overview

Cheerleading injury rates have been shown to increase with age and competitive level [2]. Cheerleading is a growing sport in Singapore, however data on cheerleading injuries amongst our local population is lacking. To our knowledge, this is the first study on the prevalence of cheerleading injuries in Singapore.

University and National cheerleaders had a higher incidence of injuries compared to Polytechnic and Open-category cheerleaders (86.8% of University cheerleaders and 83.3% of National cheerleaders, vs 44.0% of Polytechnic cheerleaders and 61.1% of Open-category cheerleaders), though the differences in team and coach demographics were not apparent. This is similar to a study by Knowles et al, which evaluated the incidence of injury among high school athletes, and found no effect of coaching qualifications and training on cheerleading injury rates [2].

### (B) Prevalence

In our study, the most common mechanism of injury was from falling from a stunt (26.8%). Other mechanisms with high injury prevalence in our study population were injuries sustained while tumbling (18.3%), injuries sustained while basing (15.5%), as well as injuries which resulted from slipping, tripping, or twisting a body part (15.5%). In particular, most injuries resulted from attempting pyramids (31.6%), running tumbling (26.3%), and partner stunts (22.8%).

Sprains and/or tears constituted the highest number of injuries amongst respondents (57.7%) in our study who sought medical attention. This is reiterated in other studies, which have reported that the most common reported cheerleading injuries were ligament sprains and muscle strains, and that the majority of injuries were found to be related to overuse [9].

### (C) Time to Injury

Cheerleaders who sustained injuries while jumping tended to have developed these injuries early into their practice sessions (within the first 60min, p=0.045).

Cheerleading jumps require sufficient warm-up time to achieve adequate elevation and flexibility. Thus, subjects may have been injured from jumping early in the practice session due to insufficient or inadequate warm-ups.

Also, we found that a higher proportion of cheerleaders fell from stunts at 61-90min and 91-120min into the practice session (p=0.010). This could be a result of fatigue and lapses in concentration late into the practice sessions.

### (D) BMI

A higher BMI has been reported as a significant risk factor for cheerleading injuries in several studies [5,6]. Our study found that a higher BMI is related to injuries sustained while basing and in collisions, while a smaller BMI is significant in cheerleaders who were injured from falling from stunts.

A possibility for the significantly lower BMI in cheerleaders injured from falling from stunts is that the difficulty level of the stunts performed could be higher in a flyer with a smaller BMI, thus adversely affecting the statistical outcomes.

### (E) Gender vs Mechanism of Injury

Males were significantly more likely to be injured while basing (p=0.025) as well as while tumbling (p=0.018) compared to females.

In mixed teams, most bases are male as they are more likely to be able to withstand the weight of the flyers, thus it can be understood how more males are injured while basing as compared to females.

Tumbling requires flexibility, and is easier for smaller, more physically compact cheerleaders to perform. Though the comparison between BMI and injuries sustained while tumbling was insignificant (p=0.551), males in general have a larger absolute body mass as compared to females, and tended to have picked up cheerleading and other flexibility-related sports later, thus more injuries tend to be sustained by males as compared to females while tumbling.

Females were found to be more likely to have fallen from stunts (p=<0.001) as compared to males. This is likely due to the fact that flyers in cheerleading teams are often female (most of the time in mixed teams, and all the time in girls' groups).

## (F) Injuries Sustained from Pyramids

In pyramids, most injuries were reported to be a result of falling from stunts (p=<0.001), as opposed to basing (p=>0.999) or spotting (p=>0.999). Falls from pyramids tend to be more catastrophic due to the height involved, especially for the flyer at the top of the pyramid.

In a 2½ pyramid, the top flyer is not in direct contact with the bases. This increases the instability of the stunt, and can translate into a greater chance of falling from the stunt.

## (G) Head and Neck Injuries in Cheerleading

3/26 (11.5%) of participants in our study who sought medical attention reported sustaining concussions from cheerleading. However, statistical analysis showed that head and neck injuries were not significantly more common than other injuries sustained in cheerleading (p=0.390 for toss, p=0.342 and 0.449 respectively for standing tumbling and running tumbling, p=0.727 for pyramids, p=0.440 for partner stunts, and p=>0.999 for jumping).

One US-based study looking into cheerleading injuries in the US found that concussions and other closed-head injuries accounted for 4% to 6% of all cheerleading injuries, and that head and neck injuries accounted for approximately 15% of all cheerleading injuries seen in US emergency departments [10].

Owing to the small number of subjects, no further subset analysis of the 3 cheerleaders who suffered concussions was performed.

## Recommendations

The National Federation of State High School Associations (NFHS) has requested for cheerleading to be included and recognized as a sport in America [11, 12]. The American Academy of Pediatrics has published recommendations for American cheerleading regulation bodies to ensure that certain guidelines are adhered to, in the hope of reducing cheerleading injuries in America [3].

We would like to offer the following recommendations to help make cheerleading a safer sport in Singapore.

1. **Adequate Rest to Reduce Overuse Injuries**
   In our survey, 91.9% of respondents reported having 3 or more practice sessions per week, and 86.5% of cheerleaders surveyed had practice sessions of more than 3 hours each. Given the high prevalence of overuse injuries like sprains and/or tears in both our study population as well as in the US amongst cheerleaders, adequate rest between sessions needs to be adhered to.

2. **Pyramids/Stunts Early into Practice Sessions, Cheer Jumps Later into Sessions**
   Injury rates from jumps were higher early into the practice session. Jumps entail elevation and flexibility, which require proper warm up exercises. Early into the practice sessions, cheerleaders might not be sufficiently warmed up to perform jumps at the intended elevation, or with the intended flexibility, and can thus be injured more easily.

   Injury rates from falling from stunts were higher late into the practice session. This could be a result of fatigue and lapses in concentration late into the practice sessions. We suggest starting out with pyramids in practice sessions, as concentration is likely to be highest early into the session. Jumps should be performed later into practice sessions when the cheerleader is adequately warmed up.

3. **Better Flexibility for Males for Tumbling**
   Males sustained significantly more injuries while tumbling as compared to females. This could be contributed by the fact that male cheerleaders tend to have had less past experience in related sports (e.g. dance, gymnastics) prior to cheerleading, thus might have more problems with stunts that require flexibility.

   We advocate more coaching and supervision for males during tumbling, as well as more flexibility training for males during practice sessions.

4. **More Spotters for Flyers During Stunts**
   In pyramids, most injuries were reported to be a result of falling from stunts. Given the potential for catastrophic injuries in pyramids, especially for the flyer at the top not in direct contact with bases, we therefore suggest increasing the number of spotters present when training for pyramids during practice sessions.

5. **Further Studies On Head and Neck Injuries in Cheerleaders**
   Concussions and head and neck injuries in cheerleaders have not been studied in Singapore, though the chance of sustaining these injuries is high given the nature of the sport. Further research needs to be undertaken on head and neck injuries amongst cheerleaders in Singapore.

## Limitations

Due to the small number of Singapore cheerleaders, the number of participants recruited was significantly fewer than that of similar studies performed in the US. This could affect the representation of injuries reported.

Also, reporting of cheerleaders with multiple injuries sustained was not accounted for.

## Conclusion

This is the first study evaluating injuries amongst cheerleaders in Singapore. Though the number of participants was small, we have managed to identify key trends in cheerleading injuries in the local scene, and are thus able to better understand the mechanisms behind these injuries, and the measures that ought to be taken to minimize them.

We hope that through this study, we can better tailor the guidelines for cheerleading coaching and practices in Singapore, and incorporate more targeted injury prevention strategies in our local cheerleading population to make cheerleading a safer sport in Singapore.

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