

# IS GYMNASTICS A DANGEROUS SPORT IN THE AUSTRALIAN CLUB CONTEXT?

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## **Abstract**

*A common perception is that the gymnastics, especially women's gymnastics, is more dangerous than most other sporting activities. This paper sought local sports injury information to consider the following questions. Is participation in gymnastics dangerous (in this case – more injurious) when compared with other popular Australian sports? Secondly, might reports of comparatively high injury rates in the USA University or Australian High Performance Institute women's gymnastics context translate to the local gymnastics club context? To consider the first question two sources of information about Australian sport injury frequency and injury rates were consulted. The first was the available state injury surveillance reports that present a comparison across sports, including gymnastics and the second source of data is Australian hospital admissions due to sport injury. To consider the second question, a compilation of gymnastics injury rate studies was undertaken. Journal articles pertaining to gymnastic injury rates were located via searches in PubMed and Google Scholar. Secondly, gymnastics injury rates studies over the last three decades are listed and considered in terms of club-based and scholastic based results to shed light on the potential injury rates in the Queensland and Australian gymnastics club context. The mean injury rate (per 1000 hours of participation) in club-level gymnastics is 2.65 (95% confidence interval 0.87 - 4.43) which is below injury rates for other popular club-level Australian sports. Based on this review, gymnastics does not present the higher hospital emergency department presentations and hospital admission injury numbers, injury rates, and types of injuries found in other Australian sports.*

**Keywords:** *artistic gymnastics, injuries, injury rate.*

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## **INTRODUCTION**

Participation in gymnastics, outside school hours, by children and youth (15 years and younger) is considerable in Australia. Gymnastics was the third highest participatory sport and recreation for females in Australia in 2009 (Australian Bureau of Statistics, 2010). A rise in the participation rate for gymnastics, along with increased skill difficulty practiced at younger ages has led to concerns regarding the risk of injury to young gymnasts (Meeusen & Borms, 1992; Sands, 2003; Singh, Smith, Fields & McKenzie, 2008).

A common perception is that gymnastics, especially women's artistic gymnastics, is more dangerous (i.e. has a higher injury rate) than most sporting activities (Singh et al., 2008). Research interest in injury to gymnasts (club, school and college) has developed along with the growth in this sport's popularity. This was particularly so in the USA scholastic gymnastics programs which had early beginnings dating back to 1825 (USA Gymnastics, 2011). Many reports of injury in gymnastics originate from USA University, school, and club communities (Caine, 2003). Gymnastics

injury rates in the USA scholastic setting, and to some extent in the USA club setting, have been seen as reasons for concern (Caine, 2003; Sands, 2000). For example, the National Collegiate Athletic Association (NCAA) Injury Surveillance System shows women's gymnastics as having the 2<sup>nd</sup> to 6<sup>th</sup> highest rates of injury in NCAA college sports (Marshall, Covassin, Dick, Nassar & Agel, 2007). In Australia, investigations of injury to elite gymnasts at State Institutes have reported high injury rates per 100 gymnasts (Dixon & Fricker, 1993; Kolt & Kirkby, 1995, 1999). A retrospective analysis of children and youth gymnastics injury data collected after USA emergency departments visits shows 4.8 injuries per 1000 hours of participation in the USA school and club setting, and this is similar to injury rates reported for other popular sports, such as basketball and soccer (Singh et al., 2008). These gymnastics injury rates in the USA (University, School and Club) and Australia (elites at State Institutes) suggest that gymnasts are as vulnerable to injury as participants in other popular sport such as American football or Rugby football (Kolt & Kirkby, 1996). Insight into the injury rates for Australian youth sports participation may be useful in the discussion of gymnastics injury rates. In Perth, Western Australia, a retrospective investigation of 1,512 Australian Rules football, field hockey, basketball and netball participants in community-based clubs returned an overall injury rate of 16.7 injuries per 1000 hours of participation. In this study, a sports injury was defined as one that occurred during sports participation and led to one of the following outcomes: a loss of sports activity, the need for advice or treatment, and or adverse economic or social effects. The injury rate was highest for Australian football (20 injuries per 1,000 participation hours), followed by field hockey and basketball (15 and 14 injuries per 1,000 participation hours, respectively) and lowest for netball (12 injuries per 1,000 participation hours) (Stevenson, Finch, Hamer & Elliott, 2003).

However, there has been little, if any, reporting of Australian club level gymnastics injury rates or consideration of comparative Australian sport injury data. University, school or institute gymnastics sporting environments can differ considerably from club based gymnastics settings. Issues of earning and holding scholarships, financially-driven competitions, high training loads and competitive event intensity make the scholastic and elite performance gymnastic sectors different in degree to local gymnastics clubs.

#### *Sporting activity and hazards*

All sporting activity presents hazards, and gymnastics has height, flight, rotation and swing that present clear hazards of slipping, tripping, falling and striking. However, nearly all hazards in gymnastics are distributed and can be anticipated and controlled. Gymnastics has a very large variety of movement skills, but involves a set of performances in a "closed" sporting skill environment. This is where the "field of play" is a set, stable and predictable environment allowing advanced organization of skilled movement (Schmidt, 1991). This allows an anticipation of hazardous consequences and the ability to control these hazards. So, while gymnastics is risky, much of the risk can be understood and the hazards controlled.

In games, such as the various footballs (rugby or soccer) hazards are also present throughout the game, but the performance is in an "open" environment which is unpredictable, unstable and prevents predetermined organization of movement (Schmidt, 1991). In most "open" sports, hazard exposure cannot be fully anticipated as these hazards are experienced in a changing game environment. The movement skills in these sport games are mainly fundamental movements and cyclical in nature (running, kicking, throwing), however the playing environment is constantly changing with "moving", colliding opponents and equipment (Bompa, 1983). Contact with

equipment and contact with another player can account for the majority of injuries in team sports (Backx, Beijer, Bol, & Erich, 1991; Radelet, Lephart, Rubinstein & Myers, 2002). This makes these sport hazards difficult to anticipate and control, and increases the variability of injury consequence.

### *Study Questions*

This paper sought local sports injury information to consider the following questions. Is participation in gymnastics dangerous (in this case – more injurious) when compared with other popular Australian sports? Secondly, might reports of comparatively high injury rates in the USA University or High Performance Institute women's gymnastics context translate to the Queensland and Australian gymnastics club context?

## **METHODS**

### *Gymnastics injury rates*

The contexts, subjects, investigative methods, and reporting of information about gymnastics has been varied and confusing (Caine, 2003). What constitutes an injury has ranged from self-reports of soreness to those requiring hospital admission. Differences in injury rates have also lent confusion to the overall record. For example injury rates have been variously described in terms of per 100 gymnasts, per 100 exposures, per 1000 hours of training exposure, per 1000 hours AE (athlete exposure = one gymnast participating in one training session or in one competition.), or simply per year per participant. Many studies of gymnastic injury have used either the number of injuries per 100 exposed gymnasts, or the number of injuries per 1000 training hours per cohort of gymnasts. The former is the rate of injury frequency or the injury rate in a given sample, while the latter is a rate of injury exposure or injury rate in a given time (Bak, Kalms, Olesen, & Jorgensen, 1994; Bruggemann, 1999; Caine, Cochrane, Caine & Zemper, 1989; Caine, Knutzen, Howe, Keeler, Fast, Sheppard &

Henrichs, 2003; Dixon & Fricker, 1993; Dowdell, 2011; Fellander-Tsai & Wredmark, 1995; Garrick & Requa, 1980; Harringe, Renström & Werner, 2007; Hume, 2005; Kolt & Kirkby, 1995; Lindner & Caine, 1990; Marshall et al., 2007; Pettrone & Ricciardelli, 1983; Sands, Shultz & Newman, 1993; Snook, 1979; Weiker, 1985).

While knowledge of the rate of injuries in a sample cohort (per/100 persons) can be useful in relation to that cohort, it does not reflect the injury rate in relation to the given time (hours) of participation (exposure). The latter injury rate (injuries/1000 hours of participation) can be a more useful in comparing sports based on hours of participation. For example, two cohorts of basketball and gymnastics athletes may both have an equal frequency rate of 1.38 per 100 athletes, but the gymnast cohort trains 15 hours per week year round, while the basketball group participates 6 hours per week during a semester season. In this case, the use of the injury rate in a given time (1000 hours of participation) would be a more valid and reliable comparative measure of these two sporting group's injury rates.

### *Data sources and presentation*

To consider the first question about participation in gymnastics being dangerous (in this case – more injurious) as compared with other popular Australian sports, two sources of information about Australian sport injury frequency and injury rates were consulted. The first was the available state injury surveillance reports that present a comparison across sports, including gymnastics. These reports contain hospital Emergency Department (ED) presentation data. The sources are the Queensland Injury Surveillance Unit (QISU), the Victorian Injury Surveillance System (VISS) reporting the Victorian Emergency Minimum Dataset (VEMD), and the Australian Sports Medicine Federation (ASMF) Sports Injury survey in the Australian Capital Territory (ACT). The second source of Australian data is Hospital admissions due to sport

injury, which include gymnastics. This was retrieved from the Australian Institute of Health and Welfare reports. The frequency data from these four reports is tabled and sports are weighted for their ranked appearance in at least two studies.

To consider whether reports of comparatively high injury rates in the USA University or Australian Institute women's gymnastics context might relate to the Queensland and Australian gymnastics club context, a compilation of gymnastics injury rate studies was undertaken. Journal articles pertaining to gymnastic injury rates were located via searches in PubMed and Google Scholar. Only those studies that provided injury frequency per sample (injury/100 persons) and, or injury rates per time (injury/1000 hours of participation) are presented in table format. Case reports were excluded as they are not necessarily representative of the gymnastics population. The ranges, means and standard deviations of the injury rates in club based studies and in scholastic-institute based studies are presented.

## RESULTS

### *Hospital sport injury survey findings - Queensland and Australia*

The first three sports injury rate reports are ED presentations for the state of Queensland 1998-1999 (Hockey & Knowles, 2000), the Australian Capital Territory 1989 (Sanders, Draper & Fricker, 1989) and the state of Victoria 1999-2001 (Cassell & Clapperton, 2002). The last report is of hospitalized sports injuries in Australia 2002-2003 (Flood & Harrison, 2006).

From a field of approximately thirteen popular sports, gymnastics ranked near last (12<sup>th</sup> and 11<sup>th</sup> respectively) in percentage of Queensland hospital ED presentations and in the injury rate per 100 persons. The top ten sports with the most Queensland hospital ED presentations in descending order where Rugby League, Rugby Union, Soccer, Netball, Basketball, Cricket, Australian Rules football, Touch Football,

field Hockey, and Martial Arts. This Queensland report also considered injury rate based on participation and reported an injury "index". This index suggests that during 1989-1990 Rugby League players (injury index = 435) were over four times more likely to be injured than in any other sport (average injury index = 100), and that gymnasts (injury index = 7) were 13 times less likely to be injured than other sports.

The 1989 Australian Sports Medicine Federation (ASMF) Sports Injury survey compared the risk factors of the various sport injury rates (per 1000 participation hours) for competitive athletes of all ages in the Australian Capital Territory (ACT). In the ASMF Sports Injury Survey the hours played were estimated from those revealed by sports injured patients while the figures for the number of participants were readily available from the various sporting organizations in the ACT. Gymnastics, with an injury rate of 0.15 per 1000 hours, ranked 10<sup>th</sup> in the given sports behind Rugby League (2.0), Australian Rules football (1.9), Rugby Union (1.9), Hockey (1.5), Squash (1.3), Basketball (1.1), Indoor Cricket (1.1), Netball (1.1), and Soccer (0.55).

In the 3-year period 1999-2001 there were 40,281 Victorian hospital emergency department presentations identified on the Victorian Emergency Minimum Dataset (VEMD) where sport or active recreation was the identified causal activity (Cassell & Clapperton, 2002). Gymnastics ranked 21<sup>st</sup> in the frequency (n=273, 0.8 % of all sports) of ED presentations in the state of Victoria for those three years. The five highest ranked sports for ED presentations were Australian football (22.0% of all sports), basketball (8.8%), soccer (6.4%), netball (6.0%), and cricket (4.9%).

Hospitalizations due to sporting injuries throughout Australia (2002-2003) show a similar small admission frequency for gymnastics (Flood & Harrison, 2006). Of the reported twenty sports (some grouped, such as water sports) gymnastics was the 9<sup>th</sup> most popular activity per 100,000 population but ranked 19<sup>th</sup> with 400

hospital admissions and 17<sup>th</sup> in hospital admission rate per 100,000 population (2.0 per 100,000 population compared to all-sports at 231.4 per 100,000 population). However, the gymnastics data included trampolining where many injuries occur in the home setting, rather than a club setting. When trampolining injuries are excluded (by removing falls from trampoline and related activities) the total of hospital admitted gymnastics injuries for 2002-2003 is approximately 225. This report presented hospital admission rates in two ways – per 100,000 population of Australia and per 100,000 participants per sport. When the hospitalization rate per 100,000 participants (in each sport) is considered, the descending order of sports with highest admission rate is: Wheeled motor sports (942.7), Roller sports (738.6), Australian Rules football (734.3), Equestrian (692.7), Rugby League (677.9), Ice & snow sports (546), Rugby Union (317), Gymnastics (excluding trampolining) (261), Soccer (242), Basketball (222), Netball (184) and Cricket (148), Field hockey (126), Combative sports (123) and Water sports (97).

#### *Weighted hospital sport injury frequency findings*

A relatively common picture emerges from these surveys of hospital ED presentations and hospital admissions for sports injuries in Australia. Table 1 below shows a frequency comparison of single (ungrouped) sports injury presentations to hospital EDs and hospitals admissions in the four Australian reports. Water sports, ice-snow sports, and combative sports are not included in this discussion as they are inclusive of several (grouped) sports.

After weighting sports for their ranked appearance in at least two studies, a common list of Australian sports with the highest injury presentation frequency presents in descending order. These sports are: Australian Rules football (35), Soccer (35), Rugby League (31), Basketball (31), Netball (30), Rugby Union (25), Cycling (22), Cricket (21), Hockey (16.5), Roller sports (15), wheeled motor sports (11),

Equestrian (9), and Gymnastics (8.5). Above all other sports in injury presentation are the football codes, followed by basketball, netball, cycling and cricket. Gymnastic sports do not present the higher hospital ED and hospital admission injury numbers and injury rates found in many other popular Australian sports.

#### *Competitive gymnastic injury rate study compilation*

The compilation of competitive gymnastic injury rate studies (see Table 2) shows a range of 5.3 to 200 injuries per 100 gymnasts and 0.44 to 22.7 injuries per 1000 hours of participation. Some of the studies presented disproportionate injury rates or had inadequate sample sizes. The reported injury rate of 22.7 injury per 1000 hours of participation (Sands et al., 1993) appears to be an “outlier” and may be a result of an injury reporting method that included very minor injuries (Hume, 2005). The reported injury rate of 200 per 100 gymnasts (Dixon & Fricker, 1993) and 198 per 100 gymnasts (Kolt & Kirkby, 1995) also appear to be outliers. These very high rates may be due to these investigations being early surveys of elite gymnasts in sports institute settings. The Hume (2005) study of elite gymnastics injuries in a New Zealand club could be considered a case study due to very low subject numbers (n =15).

Two of the studies might be representative of similar levels of competitive gymnastics club contexts outside of the USA. These are the 1990 Lindner and Caine study that reported Canadian gymnastics club rates as 30 per 100 gymnasts and 0.52 per 1000 hours. Secondly, in a soon to be published prospective study of a mid-sized Queensland gymnastics club, injury rates of 14.8 and 14.1 per 100 gymnast and 0.48 and 0.44 per 1000 hours were found for 2008 and 2009 respectively in a cohort of 85 male and female Level 3-9 gymnasts (Dowdell, 2011).

Table 1. A frequency comparison of sport injury admissions to EDs, and hospitals in the given Australian reports.

Ranked Sport #	ED or Hospital Admissions report – % of total admissions			
	ED presentations ACT 1989	ED presentations Queensland 1998-1999	ED presentations Victoria 1999-2001	Hospital admission Australia 2002-2003
1	Rugby Union 18.6%	Rugby League 15.3%	Australian Rules 22%	Australian Rules 8.6%
2	Australian Rules 15.3%	Soccer 14.3%	Cycling 14.7%	Soccer 7.2%
3	Rugby League 14.6%	Netball 9.46%	Basketball 8.8%	Cycling 6.0%
4	Netball 12.6%	Basketball 7.1%	Soccer 6.4%	Rugby League 5.7%
5	Basketball 9.6%	Cricket 6.1%	Netball 6.0%	Roller sports 5%
6	Hockey 8.3%	Rugby Union 4.52%	Roller sports 5.1%	Rugby Union 4.9%
7	Squash 6.0%	Field Hockey 3.0%	Cricket 4.9%	Wheeled motor sports 4.6%
8	Indoor Cricket 5.0%	Martial Arts 2.6%	Wheeled motor sports 4.5%	Equestrian 4%
9	Soccer 7.7%	Gymnastics 1.6%	Equestrian 3.4%	Basketball 2.7%
10	Gymnastics 2.3%	Softball 1.5%	Field Hockey 1.6%	Netball 2.5%
11		Volleyball 1.5%	Swimming 1.6%	Cricket 2.3%
Other			21 <sup>st</sup> Gymnastics 0.8%	19 <sup>th</sup> Gymnastics 0.5%
Other				20 <sup>th</sup> Field Hockey 0.4%

Table 2. *Injury rates reported in competitive gymnastics injury studies*

Study	Year	Country	Gender	Study setting	Number of subjects	Injury rate /100 gymnasts	Injury rate /1000 hours
Lindner & Caine	1990	Canada	Women	Club	178	30	0.52
Bak, Kalms, Olesen, & Jorgensen.	1994	Denmark	Women	Club	46		1.40
Bak et al	1994	Denmark	Men	Club	37		1.00
Fellander-Tsai & Wredmark	1995	Sweden	Women	Club	437	6.25	
Harringe, Renström, Werner	2007	Sweden	Mixed	Club	42		2.20
Hume	2005	New Zealand	Women Male	Elite Club	9 6		0.27
Dixon & Fricker	1993	Australia	Mixed	Elite Sport Institutes	126	200	
Kolt & Kirkby	1995	Australia	Women	Elite Sport Institutes	64	198	3.40
Kolt & Kirkby	1999	Australia	Women	Elite & sub-elite	64		5.45
Dowdell	2011	Australia	Mixed	Club	85	14.1	0.45
Garrick & Requa	1980	USA	Women	School University	98	39.8	
Garrick & Requa	1980	USA	Women	Club		22.2	
Pettrone & Ricciardelli	1983	USA	Women	Club	2558	5.3	
Weiker	1985	USA	Women	Club	766	12.4	
Weiker	1985	USA	Men	Club	107	9.3	
Caine, Cochrane, Caine, & Zemper	1989	USA	Women	Clubs	50		3.66
Sands, Shultz & Newman	1993	USA	Women	University	37		22.7
Bruggemann	1999	USA	Women	Club	79		2.50
Caine, Knutzen, Howe, Keeler, Fast Sheppard, Henrichs	2003	USA	Women	Club University	79		2.50
Marshall, Covassin, Dick, Nassar & Agel	2007	USA	Women	University	1550		6.07 (in practice)
Singh, Smith, Fields, & McKenzie	2008	USA	Women	Children at EDs 1990-2005	425900		4.80

### *Range of injury rates in the competitive gymnastics injury studies*

A direct comparison of injury rates among all the studies, even with larger subject numbers, is problematic as the age of the studies and varying investigative methods present irreconcilable differences. When the studies are considered as two subgroups, one of club-based studies (n =12) and a group of Scholastic-Institute based studies (n =7) then the range of the injury rate findings groups notably as shown in Table 3.

The mean for the injury frequency rate studies (reporting injury per 100 gymnasts) is 53.74. This includes only three scholastics based studies, two of which are “outliers” that have high injury rates at 200 and 198 per100 gymnasts respectively. No confidence interval for the mean of the injury frequency rate studies is reported. The mean for the injury exposure rates studies (reporting injury per 1000 hours participation), but excluding the 2005 Hume study and the 1993 Sands et al. study, is 2.65 (95% confidence interval 0.87 - 4.43).

Table 3. *Range of injury rates in the reported competitive gymnastics injury studies*

Injury Rate used in study	Study type		Mean	SD	95% CI Mean
	Range of Club based injury rates n =12	Range of Scholastic Injury rates n = 7			
/100 gymnasts n =10	5.30 - 50.0	39.8 - 200	53.74	77.33	-
/1000 hours Participation n = 11	0.45- 3.66	2.50 – 6.07	2.65	1.87	0.87 - 4.43

## **DISCUSSION**

### *Limitations associated with sports injury data*

The general problems associated with sports injury data have been well documented (Finch, Ozanne-Smith & Williams, 1995). In Australia there is no current available data to compare injury rates across different states, nor is it generally possible to compare injury risk across sports. Furthermore, there is no baseline against which injury prevention gains can be monitored (Australia Department of Health and Ageing, 2004). With regard to study methodology, there is a lack of standardized definitions for injury, a mixed use of injury rates, varied selection of samples, wide-ranging contexts, and a lack of reliable data collection methods. For

example, studies deriving information from medical reports are likely to be more consistent and valid than those reliant on injury questionnaires completed by a gymnast. Presentation to a hospital ED or admission to hospital is usually for the more urgent or concerning injuries. However, these reported injuries do not include all injuries suffered by participants in a sporting activity, as many are managed by sports trainers or local medical practitioners. Unfortunately, injuries managed locally are not easily surveyed or reported. Hospital ED presentations and hospital admission injury data can be effectively sourced, and as a source of currently reliable data may provide a possible picture of the more serious injury outcomes of participation in

Australian sports. Nevertheless, it must be acknowledged that generalization of hospital ED presentations to the entire population most likely underestimates the extent of the sports injury data while overstating the severity (Mummery, Schofield & Spence, 2002).

Other factors that could contribute to the discrepancy in the gymnastic injury rates reports include gender differences, event-equipment differences, and safety measures employed at different gymnastics clubs that mitigate injury, the complexity of the competitive skills being performed, the physical fitness of the sample population, and the coach to gymnast ratio (Kolt & Kirkby, 1995).

#### *Hospital sport injury survey findings – Queensland and Australia*

It is important to stress again that the injury rankings should not be used to directly compare the level of danger of particular sports as the participation (training and competition) exposure of participants can differ among the various sports. Participation in gymnastics, like all other sport activities, should be considered risky, however, the “closed” nature of the gymnastics “field of play” allows much of the risk to be anticipated and the hazards controlled.

This may account for the difference in bodily location of injury between (say) football codes and gymnastics as described in Australian hospital admissions reports (Flood & Harrison 2006). Falls (49%) and contact with other persons (33%) were the most common single mechanisms of injury in football codes, while in gymnastics (including trampolining) falls (at 76%) was the most common single mechanisms of injury. Hospital admissions were most common for fracture injury in both football codes (over 60%) and in gymnastics (over 70%). In spite of this common mechanism of injury (falls) and common type of injury (fractures), locations such as face, eye, intracranial, internal organ, spine and nervous system injuries were ever present in all the football codes, but limited in

gymnastics. For example, in 2002-2003 there were 39 admissions due to nerve and spinal cord injury throughout Australia in the football codes alone (21 in AFL, 11 in Rugby Union, 7 in Rugby League). During this time there were no admissions for nerve and spinal cord injury throughout Australia due to gymnastics (and trampolining) participation. There were 65 sports-related deaths reported after hospital admission in that year from a small number of sports, especially cycling, water sports, equestrian, motor sports, and football, however none in gymnastics.

Of interest is the similarity with regards to the most admitted sports between two hospital admission studies (Australia 2002-2003 and the NSW state report 2010). Over the period 2003-2008, the total number of hospitalisations due to sport injury in New South Wales (NSW) and the distribution of sport activities causing hospital admission had hardly changed from year to year. In that report, gymnastics was grouped under Acrobatic or Aesthetic sports and ranked 11<sup>th</sup> (1.0 %) behind team ball sports (42%), wheeled non-motor sports (11%), wheeled motor sports (6%), individual water sports (5%), Team batting sports (3.7%), Equestrian (3.3%), Ice and snow sports (3%), Athletics (1.5%), Combative sports (1.3%), and Target sports (1.1%) (Finch, Mitchell & Boufous, 2010). This is similar to the rank order of sport activities causing hospital admission in the 2003 national report. Here the team ball sports of Australian Football, Soccer, Rugby League and Rugby union ranked 1<sup>st</sup>, 2<sup>nd</sup>, 4<sup>th</sup> and 6<sup>th</sup> in admission frequency. Wheeled non-motor sports, such as cycling and roller sports, ranked 3<sup>rd</sup> and 5<sup>th</sup> respectively. Wheeled motor sports ranked 7<sup>th</sup>, equestrian 8<sup>th</sup>, batting sports (baseball, softball, cricket 11<sup>th</sup>) and target sports (basketball and netball) 9<sup>th</sup> and 10<sup>th</sup>. Gymnastics was the 19<sup>th</sup> ranked sport for hospital admissions per 100,000 population.

### *Injury rates in the competitive gymnastics injury studies*

Drawing conclusions about gymnastic injury rates in the Australian club context is problematic because of the mix of the gymnastics injury studies settings and study methods. While there appears to be a difference in the range in injury rates between the club-based studies (lower rates of injury) and the scholastic-institute based studies (higher rates of injury) only an observation of this is possible through this paper. Future investigation in a number of Australian club settings may provide useful, current data. Nevertheless, comment on some issues is possible.

Several studies confirm a significant difference in lower injury rates for non-competitive gymnasts as opposed to competitive gymnasts, or lower injury rates for lower level, lower training hours as opposed to high level, higher training hours gymnasts. The lower injury rates for beginner gymnasts and those at lower competitive levels can be due to less overall exposure, lower skill difficulty, lower exposure to take-offs and landings and lower performance stress (Bruggemann, 1999; Caine & Nassar, 2005; Caine et al., 2003; Lowry & Leveau, 1982; Meeusen & Borms, 1992; Pettrone & Ricciardell, 1987). Differences in injury rate between male and female gymnasts might have been suspected, but only one study (Lanese, Strauss, Leizman & Rotondi, 1990) considered this question directly at an inter-collegiate sports level. These investigators found no evidence for gender differences in matched sports except for gymnastics. Women gymnasts experienced 0.82 injuries per 100 person-hours of exposure as compared to 0.21 injuries for the men. The university age of the subjects, and the technically diverse event apparatus used by female and male gymnasts might explain the observed differences in this study (Lanese et al., 1990).

Lastly, there is a notable difference between the injury rates per time (1000 hours of participation) in the gymnastics studies (mean 2.65/1000 hours, 95% CI

0.87 - 4.43) and the only Australian study reporting popular club-level sports injury rates per 1000 hours participation (Stevenson, Finch, Hamer, & Elliott, 2003). The mean injury rate was 16 per 1000 hours of participation for the reported West Australian sports, and highest for Australian Rules football (20 injuries per 1,000 hours) followed by field hockey and basketball (15 and 14 injuries per 1,000 hours respectively) and then netball (12 injuries per 1,000 hours). Some of this difference may be due to the self-reporting of injury through a telephone interview that can lead to over-reporting of injury, however, reported injury rates in club-level gymnastics appear to be somewhat lower than other reported popular club-level sports in Australia. Further investigation is recommended.

### **CONCLUSIONS**

Gymnastics had a 1998-1999 hospital ED presentation rate of 12<sup>th</sup> in Queensland sports behind five football codes, netball, basketball, cricket, hockey & martial arts. In hospital ED presentations due to sporting injury in the states of the ACT (1989-1999) and Victoria (1999-2000) gymnastics ranked 10<sup>th</sup> and 21<sup>st</sup> respectively in the reported sports injury presentations. While gymnastics was the 9<sup>th</sup> most popular per 100,000 populations in Australia in 2002-2003, it ranked 19<sup>th</sup> in the number of hospital admissions and 17<sup>th</sup> in hospital admission rate per 100,000 populations. Gymnastics is ranked 7<sup>th</sup> behind Roller sports, Australian Rules Football, Equestrian, Rugby League, Ice & Snow sports, and Rugby Union when the admission rate is considered per 1000 participants in each sport.

A compilation of twenty gymnastics injury rate studies shows a large range of rates being 5.3 to 200 injuries per sample (100 gymnasts) and 0.44 to 22.7 injuries per time (1000 hours of participation). However, when the studies are considered as a group of club-based studies and a group of Scholastic-Institute based studies the range of the injury rate findings clusters

notably. For the club-based studies, the ranges are 5.30-50 per sample (100 gymnasts) and 0.45 – 3.66 per time (1000 hours participation). The scholastic-institute based studies show a range of 39.8 – 200 per sample and 3.40 - 22.7 per time. These potential differences in the range of injury rate in these settings raises questions about the difference in gymnastics training contexts and the many variables therein. Further sports injury investigation in the Australian gymnastic club context is encouraged to uncover and present current data.

Injury can, and does, occur in gymnastic sports but gymnastics does not present the higher hospital ED presentations and hospital admission injury numbers, injury rates, and types of injuries found in many other popular Australian sports. While sprains, strains and fractures predominate in all sports, face, eye, intracranial, internal organ, spine and nervous system injuries that are common in other sports were limited in gymnastics. Because of gymnastic's stable "field of play" and closed skill type the most common gymnastic hazards (i.e. falls) can be anticipated and controlled. In summary, participation in gymnastics in the Australian club context should not be considered more dangerous (injurious) than other popular sports.

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