

High injury incidence in TeamGym competition: a prospective cohort study

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TeamGym is a relative new form of gymnastics originating from Scandinavia. Little is known regarding injury incidence and injury types. The aim of this study was to examine the injury pattern and incidence in Norwegian TeamGym competition. The study is a prospective cohort, with one 10-month season [17 competitions, $n = 8418$ athlete-exposures (A-Es), a total of 1134 h of exposure]. Injury pattern, incidence and exposure during competition were collected using an injury registration form. During the competitions, 115 injuries were reported including 49 (43%) acute injuries, 58 (50%) exacerbations and eight (7%) re-injuries. The injury incidence was 50.3/1000 h or 6.8/1000 A-Es. Ankle

injuries accounted for 25.6/1000 h. A total number of 30 time-loss injuries were found, giving 27 injuries per 1000 h. The high proportion of exacerbations shows that the gymnasts competed even if they had not recovered fully from previous overuse or acute injuries. A higher injury rate was observed in competition than during the pre-competition apparatus warm-up. Eighty-four per cent of the injuries occurred in the landing phase of the gymnastic skill. No sex differences were observed. The injury rate in Norwegian TeamGym competition is high, in particular for ankle injuries.

TeamGym is a spectacular team sport in which gymnasts perform in three different disciplines. These involve advanced acrobatics on the Trampoline (small trampoline) and in tumbling, as well as a floor exercise routine, which also includes dance elements and choreography. All team members have to perform the floor exercise routine, a dynamic dance sequence. In Tumbling and Trampoline, the team has to present three different rounds with advanced acrobatic elements, but only six gymnasts are allowed to participate in each round. The performance during competition is brief; a tumble lasts for approximately 7 s per gymnast. The three rounds of tumbles performed by the team lasts for approximately 3 min, but gymnasts spend much more time in the gymnasium to prepare for these few minutes of maximal effort. Each gymnast is judged individually and the team achieves one score for the performance. This relatively recent addition to gymnastics originates from Scandinavia and is included as one of seven competition disciplines in the European Union of Gymnastics (UEG). The first European Championships were held in Finland in 1996 and the sport is now gaining popularity in Europe. In the European Championships held in Belgium in 2008, 15 countries with 641 gymnasts took part.

The injury patterns in more traditional forms of gymnastics have been examined by several authors. In artistic gymnastics, the injury incidence for girls competing at the club level up to elite level is reported to vary between 0.5 injuries and 3.7 injuries per 1000 gymnastics hours (Caine et al., 1989; Lindner & Caine, 1990; Kolt & Kirkby, 1999; Bak et al., 1994; Caine et al., 2003). The majority of injuries among female gymnasts are located to the lower extremity, and ankle sprains and knee internal derangements are the most common injury type (Kolt & Kirkby, 1999; Caine et al., 2003; Marshall et al., 2007). Upper extremity injuries are more frequent among male gymnasts, most likely due to differences in the apparatus between the male and female gymnasts (Dixon & Fricker, 1993; Bak et al., 1994).

Artistic gymnastics and TeamGym demonstrate many of the same acrobatic and dance skills, but as there are significant differences in rules, regulations and apparatus; the injury risks and patterns may also differ. However, the literature published on TeamGym is limited to the pioneer work by Harringe and colleagues from Swedish TeamGym (Harringe et al., 2004, 2007; Harringe, 2007), showing an overall incidence of 2.2 injuries per 1000 gymnastics hours (including both practice and competition time).

Comparisons of studies within or between disciplines are limited by differences in the study designs and injury definitions used, and we therefore wanted to examine the injury risk and patterns in TeamGym competition in a prospective cohort study.

Material and methods

Study design

This prospective cohort study covers one 10-month season (February through November 2008) and includes injury registration during all of the 17 national competitions in Norwegian TeamGym, where all participating athletes were invited to take part in the study. The TeamGym competitions in Norway are divided into regional and national competitions, which include the Norwegian TeamGym national cup system and the national championships finals. Our study included only national competitions in which the best teams in Norway compete, including those representing Norway in the Nordic and European Championships. The gymnasts compete in female, male and mixed competitions. In addition, gymnasts compete in three different age groups: recruits (10–13 years), junior (13–18 years) and senior (16 years or older). The exact number of gymnasts competing at the national level in Norway is not known. In order to describe the size of the cohort, we computed the number of athlete-exposures (A-Es) in competition. We summed the number of participations in the competitions, and if an athlete had more than one start in the same or different event, each start was counted (Junge et al., 2008).

Injuries and exposure were recorded through direct observation by a physical therapist (S. S. L.), who was present at all the events. She examined all injured gymnasts and recorded injuries occurring during competition or the pre-competition specific apparatus warm-up on a standard form (age, sex, injury type, location), irrespective of the need for medical attention or time loss. During the examination, the gymnast was asked questions regarding injury history to be able to distinguish between injury type (acute injury, re-injury or exacerbation); for details, see Box 1. Information about which part of the event the injury occurred in was also recorded. Even though the athletes could have more than one start in the competition, the gymnasts were never registered for the same injury more than once. In cases of severe injuries, for example if a fracture, dislocation or a severe ligament injury was suspected, the gymnast was taken to hospital for further examination. Without exception, the respective coach or gymnast informed us afterwards about the severity and

Box 1. Operational definitions used in registration of injury

Reportable injury
An injury occurred as a result of gymnastic competition, irrespective of the need for medical attention or time loss

Type of injury

Acute injury: injury with a sudden onset associated with known trauma

Overuse: injury with gradual onset without known trauma

Re-injury: injury of the same type and location as sustained previously

Exacerbation: worsening of an existing injury

Severity was based on if the injury led to:

No absence: no absence from the pre-competition apparatus warm-up or competition

Time loss: not able to continue the pre-competition apparatus warm-up or competition

Table 1. Injury rates expressed as number of acute injuries (new injuries and re-injuries)/1000 h and/1000 athlete-exposures (with 95% confidence interval) associated with sex and age group

	Injuries per 1000 h (95% CI)	Injuries per 1000 athlete-exposures (95% CI)
Sex		
Female	46.6 (31.1–62.9)	6.3 (4.2–8.4)
Male	57.6 (33.5–81.7)	7.8 (4.5–11)
Age group		
Recruit	29.8 (3.7–55.8)	3.9 (0.5–7.2)
Junior	38.8 (24.5–53.2)	5.2 (3.3–7.1)
Senior	97.6 (58.5–13.6)	14.2 (8.5–19.9)
Total	50.3 (37.2–63.3)	6.8 (5–8.6)

diagnosis. However, as we did not have access to hospital records, we had to rely on the information the coaches and the gymnasts provided (Table 1).

With regard to the exposure registration, it was not possible to base this on individual attendance records for all the athletes. Instead, it was based on the time each team used to warm up and compete and was adjusted for the number of gymnasts who took part. Total exposure was computed in hours as the sum of each team's warm-up time in each apparatus and the allotted competition time in each apparatus (3 min), times the number of active gymnasts in the team. In addition, exposure was computed separately for the pre-competition apparatus warm-up part and the competition, as recommended for team sports with a fixed competition time (Junge et al., 2008).

The study was approved by the Regional Committee for Medical Research Ethics, South-Eastern Norway Health Authority, and by the Norwegian Social Science Data Services.

Calculation of incidence and statistical analysis

The injury incidence was based on the number of new injuries and re-injuries reported. The injury incidence was expressed as number of injuries per 1000 gymnastics hours and number of injuries per 1000 A-Es with their corresponding 95% confidence intervals. Differences between the sexes, age groups, disciplines and time of injury were tested using Z-tests and chi-square tests, as appropriate. Significance was accepted at the 5% level.

Results

The cohort study consists of 8418 A-Es (recruits 1297 A-Es, juniors 5435 A-Es and seniors 1686 A-Es). During the 17 competitions, a total number of 57 acute injuries (26 injuries in warm-up, 31 in competition) were recorded during 1134 h of exposure (718 h of warm-up time and 415 h of competition exposure). This corresponds to an overall injury incidence of 50/1000 gymnastics hours (95% CI: 37–63), 35/1000 h of warm-up (95% CI: 22–50) and 75/1000 h of competition (95% CI: 48–101). Using athlete-exposure as the measure of incidence, the overall incidence is 6.8 injuries/1000 A-Es (95% CI: 4.2–8.4). Of the 57 acute injuries recorded, there were 30 time-loss injuries (26 new injuries and four re-injuries), corresponding to

Table 2. Distribution of all acute injuries (new injuries and re-injuries) exacerbations with regard to body part and injury type

	Acute injuries (new injuries and re-injuries)		Exacerbations		Total
	No absence	Time loss	No absence	Time loss	
Body part					
Neck	5	1	1		7
Upper extremities	3	3	2		8
Lower back	1	1	9	1	12
Hip, groin, thigh	2		1		3
Knee	3	6	11	1	21
Lower leg		1	4	1	6
Ankle	12	17	15	11	55
Foot/toe	1	1	1		3
Injury type					
Contusion	7	5	12	5	29
Sprain/strain	20	20	15	7	62
Fracture		4			4
Dislocation		1			1
Overuse			17	2	19
Total	27	30	44	14	115

an incidence of 27 time-loss injuries per 1000 gymnastics hours (95% CI: 17–36) or 3.6/1000 A-Es (95% CI: 2.3–4.9). We observed significant differences in overall injury incidence (injuries per 1000 h) between the senior age group (98; 95% CI: 59–136) and each of the two younger age groups ($P < 0.0001$), but not between recruits (30; 95% CI: 4–56) and juniors (39; 95% CI: 24–53; $P = 0.58$). In addition, we found no significant differences in overall injury incidence between men (58; 95% CI: 34–82) and women (47; 95% CI: 31–63; $P = 0.43$).

The distribution of all acute injuries, including new injuries and re-injuries, with regard to body part and injury type are shown in Table 2. Lower extremity injuries accounted for 41 of the 57 acute injuries (72%); 29 (51%) of them were ankle injuries, corresponding to 26 injuries per 1000 gymnastics hours (95% CI 16–35). The incidence of time-loss ankle injuries was 15/1000 h (95% CI 8–22). Only six upper extremity injuries were reported (elbow, wrist, hand and fingers). The second most commonly injured region was the knee with 7.9 injuries per 1000 gymnastics hours (95% CI 2.8–13.1). Two ACL injuries were reported and in both cases the injured gymnasts were men.

Tumbling and Trampoline accounted for the highest overall injury incidence and there was a significant difference between the two acrobatic events (66 injuries per 1000 gymnastics hours, 95% CI: 48–84) and the Floor exercise (13/1000 gymnastics hours, 95% CI: 1.7–25, $P < 0.00016$). However, there was no difference between the injury incidence associated with Trampoline (81 injuries per 1000 gymnastics hours, 95% CI 52–109) and Tumbling (51 injuries per 1000 gymnastics hours, 95% CI 28–73; $P = 0.10$).

In addition to new and re-injuries ($n = 57$), 58 exacerbations were recorded, which gives a total of

115 injuries, see Table 2 for details. Almost 85% of the injuries occurred during the landing phase, while 11% occurred during take-off. Another 4% occurred either during the run-up for Tumbling and Trampoline or during the hand support phase in skills such as round-off and handspring.

Discussion

The main finding of this study was that the overall injury incidence associated with TeamGym competition was 50.3/1000 gymnastic hours or 6.8/1000 A-Es. Moreover, ankle injuries were the most common injury type and no significant sex differences was found. Finally, the high number of exacerbations in the study show that the gymnasts competed even if they had not recovered fully from previous overuse or acute injuries.

Methodological considerations

The methodology used is original in gymnastics because of the size of the cohort and because the injury registration was carried out by the same physiotherapist, who attended all of the competitions through the season. Nevertheless, a weakness with our prospective study design is that it does not necessarily measure the magnitude of overuse injuries and pain syndromes (Bahr, 2009). Another weakness is that we only report incidence in competition. As gymnasts usually spend much more time practicing in the gymnasium preparing for competition than the short time spent in competition, our study does not describe the whole magnitude of injuries in TeamGym. Despite this weakness, our

results show that competition is a high risk situation in TeamGym.

In this study, the injury registration was based on a form used by Harringe (2007). The injury registration was prospective and the same physiotherapist attended all the competitions and carried out all the registration. This should ensure good reliability and validity of the injury registration method. In the competition, only one team competes at a time. During the preparation period before the competition starts, two or three teams are warming up at the same time. The physical therapist was located with an overview of the area and as the training and competition areas are located in a relatively small area the risk of missing injuries is limited. Even so, there is always the possibility that an injury may have been overlooked, especially slight and minor injuries. However, more serious injuries such as ankle and knee sprains usually cause pain, swelling and disability. It is therefore unlikely that a gymnast who has suffered a severe injury would have been able to continue the competition (Olsen et al., 2006).

Injury rate

The total incidence of acute injury (new injuries and re-injuries) in Norwegian TeamGym was 50.3 injuries per 1000 h or 6.8/1000 A-Es. There is a threefold difference between the youngest age group and the seniors and a 2.5-fold difference between the junior age group and the seniors. Among seniors, the incidence was as high as 98/1000 h or 14/1000 A-Es. A plausible explanation is that the juniors in general perform more advanced acrobatics than the group of recruits, and among the seniors one will find an even demanding level of gymnastics. We do not have data about the amount of training, but most of the teams practice three or more times per week, each session lasting between 1.5 and 2.5 h. As we are lacking data, one can only hypothesize that the higher injury incidence among the senior group is caused by the more advanced tricks/element they perform. Another explanation might be that they are not well enough prepared for competition.

There is no other study that has investigated the injury rate in TeamGym competition. Therefore, it is not possible to compare our results directly with other findings. In the work by Harringe et al. (2007), the total injury incidence was reported to be 2.2/1000 h, including both practice and competition time. The higher injury incidence found in the present study compared with Harringe et al. (2007) could be explained by the difference in exposure time. Injury surveillance data from American collegiate women's gymnastics describe a two times higher risk of sustaining an injury in competition vs practice. Incidence is reported per 1000 A-Es. In competition,

the risk of injury is reported to be 15/1000 A-Es (Marshall et al., 2007). This is in line with the senior group in our study (14/1000 A-Es).

In our study, 50% of the injuries reported were exacerbations of injuries already sustained. It is a weakness in our study that we do not know whether they were sustained in competition or in practice. A study by Harringe et al. (2004) has shown a high prevalence of symptoms from injuries on the day of competition. A total of 58% of the gymnasts ($n = 110$) reported 147 injuries, of which 81% were sustained during practice and 12% during competition (Harringe et al., 2004). This result, along with the high number of exacerbations in our study, supports the impression that gymnasts both practice and compete in spite of injuries. This could increase the risk of more severe injuries, as seen by the high number of exacerbations in the present study.

Injury pattern

Our findings show that the highest injury risk is to the lower extremities. More than 70% of the injuries that occurred in competition were located in the lower extremity and the ankle joint alone accounted for approximately 50% of the injuries. This is in line with earlier results regarding injury pattern from both artistic gymnastics and TeamGym (Bak et al., 1994; Caine et al., 2003; Caine & Nassar, 2005; Harringe et al., 2007). The rate for a severe ankle injury in competitions was as high as 15 injuries per 1000 h. Ankle injuries are a common problem in team sports that involve jumps, landings and cutting maneuvers. In volleyball, ankle injuries are reported to account for more than 40% of the injuries with an incidence of 1 injury per 1000 h (Bahr & Bahr, 1997) (Verhagen et al., 2004). Results from international handball tournaments reveal that when injury severity was recorded the most frequently injured body part was the ankle (18%) (Langevoort et al., 2007). Ankle sprains have also been reported to be the predominant diagnosis in basketball (Junge et al., 2006).

Knee injuries are common in team sports, and ACL injuries in particular, cause great concern (Myklebust et al., 1997; Myklebust et al., 1998; Tegnander et al., 2008; Walden et al., 2011). In our study, 16% of the injuries were knee injuries and six were severe, including two ACL injuries. Still, the number was somewhat lower than expected due to the fact that the gymnasts perform advanced acrobatics, which include landings from great heights. We know from other sports that a one-leg landing after a jump is a high-risk situation (Myklebust et al., 1997; Myklebust et al., 1998; Krosshaug et al., 2007). In gymnastics, when advanced acrobatics are performed the gymnasts lands on two legs. This might be a

plausible explanation for the relatively low number of lower extremity injuries in this study.

TeamGym differ from other team sports by the fact that during the warm-up time before competition the teams perform gymnastics of the same kind as they will do in the competition. Still, we found that a greater proportion of the injuries occurred in competitions. A possible explanation for this could be that the coaches are using spotting (support/assistance) more frequently during the warm-up period than in competition. In this way, the gymnasts are more protected (Sands et al., 1993). Sands (2000) has also suggested that the higher competition injury rates could be a result of the fatigue gymnasts develop when performing full routines. The majority of the injuries occurred in the landing phase after performing acrobatic elements in either the Tumbling or Trampoline event. The injury pattern must be considered in relation with the nature of the sport. Gymnasts land from great heights while performing elements with twist and rotations (Sands, 2000; Marshall et al., 2007).

There were no sex differences regarding injury rates, which is in line with results from Swedish TeamGym (Harringe et al., 2007). In this case, our results differing from other team sports were because of gender differences (Bjordal et al., 1997; Powell & Barber-Foss, 2000; Tegnander et al., 2008).

The high risk of injuries in TeamGym is a concern, in particular, of the rate of ankle injuries. In addition,

our results show that the gymnasts compete in spite of pre-existing injury.

Perspectives

In order to describe the whole magnitude of injuries in TeamGym, a prospective cohort study that covers both practice and competition is needed. In addition, to develop effective methods for injury prevention there is a need for further studies that investigate the injury mechanisms in TeamGym, to generate hypotheses on how injuries may be prevented. Furthermore, randomized intervention studies are needed to investigate the effect of intervention programs designed to reduce injuries.

Key words: TeamGym, gymnastics, epidemiology, incidence.

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