EPIDEMIOLOGICAL STUDY OF INJURIES IN CLUB-LEVEL RHYTHMIC GYMNASTICS

A Thesis Submitted to the College of Graduate Studies and Research in Partial Fulfilment of the Requirements for the Degree of Masters in the College of Kinesiology

University of Saskatchewan

Saskatoon

By

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Fall 2002

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ABSTRACT

EPIDEMIOLOGICAL STUDY OF
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GYMNASTICS

A prospective study on club-level Rhythmic Gymnastics injuries was conducted over a six-month period on Australian rhythmic gymnasts ranging in age from 13 to 20 years. Complete responses were returned from ten gymnasts. The following data were analyzed: the number of hours trained per week, anatomical location of injury, side of body, nature of injury, type of injury, timing of injury, cause of injury, missed training, and current health status. A total of 38 injuries were reported, 10 of which were sustained by the lower-level gymnasts (1.89 injuries per 100 hours) and the remaining 28 were sustained by the higher-level gymnasts (1.65 injuries per 100 hours). Of the 38 injuries, 24 were chronic and 14 were acute. Most injuries occurred to the leg. The most common injury classification was strains. The majority of all injuries occurred during a training session versus competition and while gymnasts were practicing skills rather than practicing routines. Gymnasts sustained more injuries during warm-up than during any other segment of training and perceived the primary cause of their injuries to be due to overuse or fatigue

Although the sample size was too small to allow statistical conclusions to be reached, the trends were evident in the data. It appears that club-level rhythmic gymnasts who are most at risk of injury are characterized as being:

(1) at a high-level of club gymnastics, (2) warming up, (3) training in a session three hours in length, and (4) training when fatigued.

ACKNOWLEDGMENTS

The author wishes to thank Gymnastics Australia for approving this study to be conducted using their gymnasts. Thanks must also go to the three clubs involved in the six-month study – Moreton Bay College Gymnastics Club, Splitz Club of Gymnastique, and St Margaret's Gymnastics Club.

Most of all I would like to thank Dr Keith Russell for all his inspiration and words of wisdom.

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Chapter One

1.1 INTRODUCTION

Participation in women's sport is increasing, particularly due to the media attention generated from the Olympic Games and the concerns of the health and medical communities (Hutchinson, Benardot, & Balague, 1999). Rhythmic Gymnastics is a relativity new sport. It was formally endorsed by the International Gymnastics Federation (FIG) in 1962 and in Australia it was first introduced in 1975. It is characterized by athleticism, elegance, and skill. Rhythmic Gymnastics has been described as a combination of Artistic Gymnastics and ballet (Weiker, 1989), and can be distinguished by the use of hand apparatus (rope, hoop, ball, clubs, and ribbon) and a high degree of flexibility throughout movements.

There is currently a paucity of comprehensive research published documenting the nature, etiology, severity, and prevalence (total number) incidence rates (rates per 100 hours of training) of injuries sustained by Rhythmic Gymnasts. Without this information, it is difficult to provide coaches, athletes, parents, governing bodies, and sports medicine professionals with information required to understand and prevent Rhythmic Gymnastics injuries. As Rhythmic Gymnastics is similar to both Artistic Gymnastics and ballet, research on these sports was reviewed to assist in forming a preliminary understanding of injuries in Rhythmic Gymnastics. A research protocol was

developed for the current study following this literature review. The aim of this study was to investigate the prevalence and the incidence rates of injuries sustained by Australian club-level rhythmic gymnasts.

1.2 REVIEW OF LITERATURE

1.2.1 Sports Injuries

It is necessary to investigate the prevalence and etiology of sport injuries, given the physical, emotional, and economic impact that they have on athletes (Whiting & Zernicke, 1998). Research needs to be undertaken in an attempt to reduce the prevalence of injuries sustained by these athletes. If the sporting community fails to implement the preventative measures yielded from research, investigators have failed to reduce the prevalence of injury. Indeed, Janda (1992) found that numerous sporting communities often rejected recommendations made by researchers concerning protective rules and the use of protective equipment. Often the sporting communities were reluctant to change tradition and ignorant of protective measures (Janda, 1992).

The lack of uniformity in defining an injury is a major limitation of existing sporting injury research. Without such consistency, it is very difficult to compare studies (see Table 1.1). Whiting and Zernicke (1998) defined injury as "the damage caused by physical trauma, sustained by tissues of the body." This definition is difficult to apply when investigating sports injuries, as it does not clearly define injury. Several researchers have defined injury as " ...any incident that required medical attention" (van Mechelen, Hlobil, & Kemper, 1992). This has proven to be an inadequate definition given that van Galen

and Diederiks (1990, cited in van Mechelen et al., 1992) found that only 43% of all injuries are medically treated. A more encompassing definition is given by Rice (1989), who defined sports injury as "a medical condition, resulting from athletic activity, that causes a limitation or restriction on participation in that activity or for which medical treatment was received." Defining an injury as "resulting in a limitation or reduction of activity" increases its sensitivity and makes the definition applicable to a greater number of injuries. Despite the increase in sensitivity, Rice's (1989) definition is still not sensitive enough to account for all injuries, particularity those sustained by athletes. Indeed, competitive athletes are often so dedicated to their sport that they train while injured and/or in pain and frequently not acknowledge the limitation or restriction of their injury on their performance. Unfortunately the philosophy of "No Pain, No Gain" still exists in competitive sport.

Another disparity in existing sports injury research is the difference in the level of the athletes involved. It is thought that the level of the athlete will influence their exposure time to injury, with higher-level athletes having a higher exposure time to injury. To compensate for this difference, researchers often report injuries as an incidence rate (e.g., the number of injuries per 1000 hours of training).

Table 1.1 Definitions of sport injuries used in research

Study	Definition
Lowry & Leveau (1982)	Any condition which required treatments and/or limited participation for one class period or one practice
Rice (1989)	A medical condition, resulting from athletic activity that causes a limitation or restriction on participation in that activity or for which medical treatment was received.
Van Mechelen et al. (1992)	One sustained during sporting activities for which an insurance claim is submitted
Van Mechelen et al. (1992)	Injuries treated at a hospital casualty or other medical departments
Baxter-Jones et al. (1993)	One which occurred as a result of participation in sport which had one or both of the following consequences (a) a reduction in the amount of level of sports activity or (b) need for treatment or advice.

Injuries are typically divided into two categories: acute and chronic. An acute injury is defined as sudden in onset, severe in intensity, and brief in duration (Micheli, 1984; Baxter-Jones, Maffulli, & Helms, 1993). This type of injury includes: strains, sprains, dislocations, and fractures. Acute injuries typically have the highest frequency in sport (Lowry & Leveau, 1982; Pettrone & Ricciardelli, 1987; Knapik, Bauman, Jones, Harris, & Vaughan, 1991). In contrast, chronic injuries are defined as habitual or long-term injuries (Micheli, 1984; Baxter-Jones et al., 1993). Without adequate recovery from injury, the microtrauma stimulates an inflammatory response, which, in turn, results in localized damage to the area (DiFiori, 1999). Stress fractures, tendonitis, and shin splints are examples of chronic injuries. The nature of the sport will

determine the probable percentage of chronic injuries. Sports that involve repetitive actions are more likely to induce chronic injuries in the joints/limbs.

The majority of existing sports injury studies have been epidemiological-based research. These studies investigate "the distribution and determinants of varying rates of disease, injuries or other health states in human population for the purpose of identifying and implementing measures to prevent their development and spread" (Caine, Lindner, Mandelbaum, & Sands, 1996). Epidemiological studies can be either descriptive or analytical. Descriptive epidemiology is the most widespread and describes the frequency, distribution, severity, and location of injuries in a given population (Whiting & Zernicke, 1998). In contrast, analytical epidemiology endeavors to identify the causal relationship of an injury. These types of studies are scarce but are fundamental in establishing and understanding the etiology of injuries.

Epidemiological research can be either retrospective or prospective. Retrospective studies are not optimal, as they require the athlete to recall their injury history for up to 18 months prior to the interview. Peoples' ability to recall the existence and details of previous injuries varies considerably and, thereby, reduces the accuracy of the results. Kolt and Kirkby (1999) compared the results of a retrospective and prospective study of female artistic gymnasts and found that a significantly higher number of injuries were recorded in the prospective study compared to the retrospective study. Interestingly, however, Kolt and Kirkby (1999) found that there was no significant difference in the distribution of injury or type of injury between the two types of studies. These

results suggest that prospective studies are the superior method to use when conducting injury research. Indeed, the majority of gymnastics injury studies have been prospective (Pettrone & Ricciardelli, 1987; Goodway, McNaught-Davis & White, 1989; Weiker & Ganim, 1989; Kolt & Kirkby, 1999).

1.2.2 Factors that predispose one to injury

Mechanisms are the "fundamental physical processes responsible for a given action, reaction or results" (Whiting & Zernicke, 1989). Through identifying the mechanisms of an injury, one can then ascertain the cause-effect relationship. Numerous authors have suggested mechanisms that cause injury (factors that predispose one to injuries), as:

1. Age (Slottow, 1978; Caine & Lindner, 1985; Whiting & Zernicke, 1989)
2. Gender (Whiting & Zernicke, 1989)
3. Genetics (Whiting & Zernicke, 1989)
4. Growth spurt (Slottow, 1978; Caine & Lindner, 1985; Whiting & Zernicke, 1989)
5. Nutrition (Whiting & Zernicke, 1989; Baxter-Jones et al., 1993)
6. Psychological status (Whiting & Zernicke, 1989)
7. Fatigue (Whiting & Zernicke, 1989)
8. Environment (Whiting & Zernicke, 1989)
9. Equipment (Whiting & Zernicke, 1989)
10. Previous injury (Whiting & Zernicke, 1989)

11. Anthropometric variability (Micheli, 1984; Whiting & Zernicke, 1989; Caine & Lindner, 1990)
12. Skill level (Micheli, 1984; Whiting & Zernicke, 1989)
13. Experience (Whiting & Zernicke, 1989)
14. Uneducated coaches (Caine & Lindner, 1990)
15. Technique (Micheli, 1984; Caine & Lindner, 1990)

1.2.3 Injury in Children

A report by the International Federation of Sports Medicine (1990) indicated that the prevalence of injuries in children is increasing. There has also been an increase in the number of children participating in organized sport, particularly at an international level (Baxter-Jones et al., 1993; DiFiori, 1999). Children are specializing in sport at an early age, resulting in their bodies being exposed to intense physical training prior to puberty (Baxter-Jones et al., 1993; Mansfield & Emans, 1993; DiFiori, 1999). This trend appears to have resulted in an increase in overuse injuries amongst children (International Federation of Sports Medicine, 1990). It has been suggested that overuse injuries arise from the tissue growth in childrens' bodies and muscle imbalance surrounding joints (Caine & Lindner, 1985; Caine, Cochrane, Caine, & Zemper, 1989; International Federation of Sports Medicine Report, 1990). Moreover, the pubertal growth spurt is a vulnerable period for this kind of injury (Micheli, 1983; Caine et al., 1989; Caine & Lindner, 1990; Baxter-Jones et al., 1993). More specifically, the increase in

bone length during the growth spurt increases the muscle-tendon tightness (Slottow, 1978; Micheli, 1983; Caine & Lindner, 1985; Schootman, Powell & Torner, 1994). Muscle-tendon tightness, in turn, decreases an individual's flexibility and, consequently, increases the likelihood of tissue strain (Micheli, 1983). An additional variable is that muscle strength is not increasing at the same rate as bone length. Consequently, it is thought that children are more susceptible to skeletal overuse injuries (Caine & Lindner, 1990).

As a result of the increase in the depth of the physis (apophyseal and epiphyseal) and its relative weakness compared to the surrounding fibrous tissue, the growth plates are more vulnerable to shear-type injuries during the growth spurt (Caine & Lindner, 1990). McNaught-Davies (1986) suggested that even over-stretching the muscles and ballistic stretching could damage the physes during puberty. Schootman et al. (1994) suggested that excessive pressure placed on the growth plate during this time could arrest bone growth. Schootman (1994), however, did not indicate the value for excessive pressure. It was also suggested that the spine was the most vulnerable site for injuries because the growth plates are exposed to both the pressures from movement and powerful muscle contractions.

1.2.4 Injury Characteristics in Similar Sports

Due to the paucity of research available on Rhythmic Gymnastics, similar sports (Artistic Gymnastics and Ballet) were reviewed to help develop hypotheses.

1.2.4.1 Women's Artistic Gymnastics

Research has suggested that Artistic Gymnastics could be compared to Rhythmic Gymnastics (Meeusen & Borms, 1992). Gymnastics experts, however, find few similarities between the two sports. The primary similarity between the two sports is the use of the floor as an equipment/apparatus. Until recently, rhythmic gymnasts were unable to perform any acrobatic skills. Therefore, only similarities were the dance elements the gymnasts performed. Recently, however, rhythmic gymnasts have been permitted to perform walkovers and cartwheels in their routines. This slightly increases the similarity to the artistic floor.

Apparatus

Of the four apparatuses in Women's Artistic Gymnastics, the majority of injuries (34%) have been found to occur on the floor (Lowry & Leveau, 1982; Pettrone & Ricciardelli, 1987; Caine et al., 1989). Artistic gymnasts, however, spend a substantial amount of time on the floor preparing for other apparatuses, including: warm-up, physical preparation, ballet/dance, choreography, floor apparatus, beam preparation, vault preparation, and warm-down. With such a large percentage of training on the floor, one would expect more injuries to be sustained on the floor. Female Artistic Gymnastic places an enormous demand on the lower extremities and spine. These demands include jumping, landing, and twisting/turning. It is, therefore, not

surprising that the lower extremities and spine sustain the most injuries (Caine & Lindner, 1985; Caine et al., 1989; Dixon & Fricker, 1993; Kolt & Kirkby, 1999).

Timing of injury

Artistic Gymnastics has increased in popularity amongst children (Caine & Lindner, 1985; Meeusen & Borms, 1992). Unlike many other sports, Artistic and Rhythmic Gymnastics are not seasonal. Caine et al. (1996) indicated that elite artistic gymnasts train between 30 and 40 hours a week, across five and six days. Furthermore, it has been reported these elite gymnasts perform 700-1300 skills per day (Caine et al., 1996). The characteristics of Artistic Gymnastics are important when trying to understand the etiology of the injuries sustained. Pettrone and Ricciardelli (1987) suggested that a positive correlation exists between the prevalence of injuries and the duration and frequency of practice amongst artistic gymnasts. In a study by Caine et al. (1989), however, 23% of sudden onset injuries and 61.5% of strains occurred during the first hour of training. The authors suggested that this resulted from insufficient warm-up. While training duration and intensity for rhythmic gymnasts have not been documented, it is the author's opinion that they train for fewer hours than artistic gymnasts.

Type of injury

Caine and Lindner (1990) hypothesized that an increase in the type of injuries in artistic gymnasts is due to the significant increase in the difficulty of skills being performed in competitive gymnastics, the intense training undertaken, and the tremendous repetitive stress placed on gymnasts' underdeveloped skeletal system. Discrepancies exist in the literature regarding the nature of injuries sustained by artistic gymnasts. Both Pettrone and Ricciardelli (1987) and Dixon and Fricker (1993) found that artistic gymnasts sustained a higher prevalence of acute injuries than chronic injuries. Indeed, strains, sprains, contusions, and fractures have been found to be the most common type of injury (Lowry & Leveau, 1982; Pettrone & Ricciardelli, 1987). Caine et al. (1989), however, found that artistic gymnasts sustained a greater number of gradual onset injuries (56%).

Unfortunately, the prevalence of reinjury in artistic gymnasts is high, with Caine et al. (1989) finding that 32.7% of injuries sustained were reinjuries. Although Caine et al. (1989) were unable to explain the high incidence rate of reinjury, they suggested that it could be the result of underestimating the severity of the original injury, inadequate rehabilitation, and/or returning to training prematurely.

The five primary reasons for artistic gymnasts sustaining injuries have been determined to be: (1) missed skills, (2) contact with and falling from the apparatus, (3) dismounts, (4) incorrect landings, and (5) twisting dismounts (Pettrone & Ricciardelli, 1987; Meeusen & Borms, 1992). Given the

aforementioned information, the author hypothesized that the following would pertain to rhythmic gymnasts: (1) missed skills, (2) contact with the apparatus, and, (3) incorrect landings.

Certain artistic gymnasts are at a higher risk of sustaining injuries. Pettrone and Ricciardelli (1987) proposed these gymnasts are those: (1) at an advanced competitive level, (2) performing floor and beam, and (3) training 20 or more hours per week. Based on this information, the author predicts that an advance level rhythmic gymnast training 20 or more hours a week would be at high risk of injury.

Research on Artistic Gymnastics injuries has been hindered by: (1) the lack of documentation kept by coaches and clubs regarding their gymnasts' injuries (Sands, 1981) and (2) gymnasts are known to ignore pain and continue training without seeking medical attention or reducing their training (Slottow, 1978). It is anticipated that the similar issues will be faced when collecting data from rhythmic gymnasts.

1.2.4.2 Ballet

The elements required in Rhythmic Gymnastics routines are predominantly ballet/dance movements. Indeed, rhythmic gymnasts and ballerinas share many characteristics. Howse and Hancock (1992) suggested that dancers would have difficulty executing movements correctly if they were not anatomically designed for ballet. Incorrect technique has been suggested to be the primary cause of ballet injuries as it causes muscle strain and places

structures under undue stress (Anaheim, 1986; Howse & Hancock, 1992). To prevent injuries, Howse and Hancock (1992) suggested that ballet dancers should work to their physical capacity rather than pushing their bodies beyond this by using incorrect technique. Although not documented, it is believed that using incorrect technique would be the primary cause of injuries sustained by rhythmic gymnasts, given they perform similar movements to ballerinas. The only way to confirm this hypothesis is to observe a large number of training sessions. Incorrect technique can also develop from dancers compensating for existing injuries (Macintyre & Joy, 2000) as they are prone to further injury through the development of a kinetic chain dysfunction. This dysfunction results from incomplete rehabilitation of an injury and compensation with an alternative movement pattern (Macintyre & Joy, 2000). It is not surprising, therefore, to find that 90% of dancers in Ramel, Moritz, and Jarnlo's study (1999) suffered from recurring pain.

An interesting theory by Arnheim (1986) suggested the unique characteristics of ballet dancers' bodies allows them to excel but also predisposes them to a variety of injuries. These body characteristics are both inherent and trained. Together with these body characteristics, Arnheim (1986) also suggested that biomechanical characteristics predispose ballet dancers to injuries, including: (1) abnormal angles of muscle pull, (2) misalignment of body parts, (3) a sudden forceful twist, and (4) a breakdown in the normal synergy of a muscle or muscle group. These predispositions to injury could also apply to rhythmic gymnasts. A substantial number of the skills

requiring extreme ranges of movement performed by ballerinas are requirements of both ballet and rhythmic gymnastics.

There is a paucity of research concerning ballet injuries. Several books, however, have been published on dance injury mechanisms and injury prevention (Arnheim, 1986; Schafle, Requa, & Garrick, 1990; Howse & Hancock, 1992). Some similarities exist between the etiologies of injuries in ballerinas and artistic gymnasts. Unlike artistic gymnasts, however, female ballet dancers only suffer from lower extremity and spinal injuries (Schafle et al., 1990). Krasnow, Mainwaring, and Kerr (1999) found that ballet dancers and gymnasts sustained more hip injuries than the general female population. It is conceivable that ballet dancers do not sustain upper extremity injuries, given that they seldom weight bear on their upper extremities, except during lifts. However, a high prevalence of chronic injuries has been reported amongst ballet dancers (42%) (Schafle et al., 1990). This suggests that ballet dancers undergo a large amount of repetitive stress that results in a substantial number of chronic injuries. Perfectionism is a common trait of both ballet dancers and gymnasts, which makes them more susceptible to injuries. The author hypothesizes that like ballerinas, rhythmic gymnasts will have a large percentage of chronic injuries, because of the similarities that exists between the movements performed by ballerinas and rhythmic gymnasts.

1.2.4.3 Rhythmic Gymnastics

The similarities that exist between Artistic Gymnastics, ballet, and Rhythmic Gymnastics should assist in the investigation of injuries sustained by rhythmic gymnasts. A stronger link appears to exist between the skills in ballet and Rhythmic Gymnastics than between Rhythmic Gymnastics and Artistic Gymnastics. A better comparison, therefore, can be made between Rhythmic Gymnastics and ballet (Meeusen & Borms, 1992). Meeusen and Borms (1992) stated that rhythmic gymnasts suffer from a number of ballet-like ankle and foot injuries. No evidence, however, was provided to support their statement. As with ballerinas, the majority of movements performed by rhythmic gymnasts require excessive range of motion, which are technical requirements of the sport. Appendix A illustrates a number of movements performed by rhythmic gymnasts that require excessive range of motion. It is possible that the technical requirements set by the FIG may contribute to some injuries. If a relationship between the aforementioned technical requirements and injuries could be shown to exist, rule changes could be recommended to reduce the prevalence of injury.

Elite level rhythmic gymnasts train slightly less hours than elite artistic gymnasts (20-36 hours/week versus 30-40 hours/week). Given that artistic gymnasts and ballet dancers are both susceptible to overuse injuries from repetitive work (Pettrone & Ricciardelli, 1987; Howse & Hancock, 1992; Meeusen & Borms, 1992), it could be anticipated that rhythmic gymnasts would have a similar pattern of overuse injuries. Rhythmic gymnasts also

strive for perfection. Repeatedly performing and perfecting their skills achieve this. Thus, the repetitive nature of the sport is hypothesized to place the gymnasts at an increased risk of sustaining injuries.

Hume et al. (2000) recently investigated the prevalence of injuries in elite New Zealand rhythmic gymnasts. The results of this study cannot be generalised, however, given that only four elite gymnasts were followed for a one-month period. Through the duration of Hume et al.'s (2000) investigation, only one injury was reported. In the only other study investigating Rhythmic Gymnastics injuries, Hutchinson (1999) documented the prevalence of low back pain in seven elite rhythmic gymnasts for a seven-week period. Hutchinson (1999) found that 86% of the gymnasts reported pain during this period. In turn, this indicated that this group of rhythmic gymnasts was at high risk of sustaining lower back injuries. Further investigation is necessary, however, to establish the etiology of back pain.

By documenting the nature, etiology, severity, prevalence and incidence rates of injuries in Rhythmic Gymnastics, it is possible to provide coaches and sports medicine professionals with the necessary information to aid in predicting or preventing Rhythmic Gymnastics injuries.

1.3 STATEMENT OF THE PROBLEM AND THE HYPOTHESES

1.3.1 Statement of the Problem:

What are the: nature, etiology, severity, prevalence and incidence rates of injuries sustained by club-level rhythmic gymnasts in selected Australian clubs?

1.3.2 Statement of the Hypotheses:

From the results yielded from similar groups (Artistic Gymnastics and ballet) it is hypothesized that:

Rhythmic gymnasts will sustain:

Hypothesis 1. More acute injuries than chronic injuries

Hypothesis 2. More injuries to the leg and pelvis than to the trunk, neck and arm

Hypothesis 3. More injuries during the last quarter of daily training

Hypothesis 4. More injuries when training time is three hours

Hypothesis 5. More injuries resulting from basic skills than from advanced skills

CHAPTER TWO

METHODOLOGY

2.1 Research Design:

This study involved two parts. Part 1 was a retrospective questionnaire in which gymnasts recalled injuries sustained in the six-months prior to commencing the study. This part was included to familiarize participants with the questionnaire and to provide information concerning previous injuries. Data collected in Part 1 was not used in the final analysis. Part 2 was a six-month prospective study of injuries.

For the purpose of this investigation, an injury was defined as **"any event that (1) requires a medical professional and/or (2) results in a restriction in training or performance."**

2.2 Subjects

Gymnastics Australia sent out information regarding the study to all State teams who would be attending the 2000 National Championships and the author approached additional Queensland clubs. One hundred and five gymnasts throughout Australia and New Zealand consented to participate in the study. Only 15 gymnasts, 14 club-level and one elite gymnast, from Australia continued to participate. Participants in this study were from four clubs, three of whom were based in Queensland. As only one elite gymnast

agreed to participate in the study, the data pertaining to this gymnast was excluded. Of the 14 club-level gymnasts, only 10 gymnasts completed surveys for the entire six-month period. The four gymnasts who did not complete the full six-months retired from competitive Rhythmic Gymnastics after completing three months of the study. These gymnasts did not retire as a result of injury.

The club-level gymnasts were competing in the Gymnastics Australia's club-level program. The club-level gymnasts involved in the study ranged from Level 5 to Level 9. All gymnasts participating in the study competed at the 2000 State Championship and all of the Level 7-9 gymnasts competed at the 2000 National Levels Championships. Based on this, gymnasts were categorized into two groups – Level 5-6 (lower) and Level 7-9 (higher). These gymnasts were competitive and trained at least six hours a week. Participants were also old enough to comprehend the questions comprising the questionnaire and requirements of this study.

2.3 Procedures

Information relating to the study was supplied to Gymnastics Australia, the National Rhythmic Gymnastics Technical Committee, State Gymnastics Associations, and state coaches. Consent was required from the gymnasts, coaches, and parents before the gymnasts were included in the study (see Appendix C and D). Approval was also obtained from the University of Saskatchewan and Gymnastics Australia Ethics committees (see Appendix B).

2.3.1 Instrumentation

The questionnaires were developed by reviewing the Ontario Gymnastics Injury Study of 1988 and the University of Saskatchewan Gymnastics study of 1991. The questionnaires were first evaluated for content validity by 10 experts in the area of sports injuries and questionnaire design and were adjusted based on their recommendations. Both retrospective questionnaires and prospective questionnaires were given to the all participants.

2.3.2 Part 1

Part 1 consists of two questionnaires. The General Information questionnaire contained questions regarding age, years in Rhythmic Gymnastics, current level, years at this level, others sports, maximum number of hours in one training session, hours trained per week, the breakdown of training sessions, preferred hand, preferred leg, pivoting direction, gymnasium floor surface, number of gymnasts in squads, number of coaches supervising group at one time, menstrual status, and current injury status (see Appendix E).

The retrospective questionnaire was designed to track injuries sustained six-months prior to the commencement of the study. Information was yielded regarding: the anatomical location, side of body, nature of injury, type of injury, timing of injury, cause of injury, missed training, and health status (see

Appendix F). To ensure that participants fully understood the terms comprising the questionnaire and, thereby, to reduce errors made due to misunderstanding, the investigator traveled to Rhythmic Gymnastics competitions and training camps throughout Australia to administer the retrospective questionnaire.

2.3.3 Part 2

While conducting Part 1 of the study, the investigator distributed and explained the prospective questionnaire to the gymnasts and coaches.

Participants completed a weekly injury questionnaire for a six-month period. Gymnasts indicated if an injury was sustained, the number of hours trained that week, anatomical location, side of body, nature of injury, type of injury, timing of injury, cause of injury, missed training, and current well-being. If more than one injury was sustained in a week, multiple copies of the injury report form were completed (see Appendix G).

To ensure compliance in completing Part 2 of the study, the gymnast's coach or the investigator collected the weekly injury report forms. The investigator collected forms from all Brisbane-based gymnasts. To ensure confidentiality, gymnast handed their forms to their coach in a sealed envelope or folder or directly to the investigator. The investigator contacted the coaches/gymnasts regularly by telephone, mail and, email to discuss their progress or any problems that may have arisen.

2.4 Statistical analysis

2.4.1 Descriptive Statistics

Frequency distributions were tabulated (using an Excel spreadsheet) for each level and the overall group. Frequency distribution was used to determine the number and percentage for a range of parameters including:

- Body part injured
- Nature of injury
- Side of injury
- Classification of injury
- Training session versus competition injuries
- Time period when injury occurred
- Length of training
- Skill difficulty when injured
- Routines versus skill training
- Perceived cause of injury
- Pain level

- Missed and modified training time
- Health status each week
- Percentage of athletes with one, two, three and greater than five injuries

The incidence rate of injury was calculated by dividing the total number of injuries sustained by the number of hours trained then multiplying by 100. This was calculated for the whole group and each individual group (i.e. Level 5-6 and Level 7-9).

Chapter Three

RESULTS AND DISCUSSION

3.1 General Information

A total of 105 gymnasts were approached to participate in this injury study, however, only 10 gymnasts were monitored for a six-month period, three of whom were Level 5-6 gymnasts and seven were Level 7-9 gymnasts. The high attrition was believed to be the result of coach bias against research. As a result of the low number of gymnasts, inferential statistics could not be calculated. The average age of the total sample was 15.80 (SD=2.04). Level 5-6 gymnasts ranged in age from 13 to 15 years, with an average of 14.33 (SD=1.15), while the age range for the Level 7-9 gymnasts was from 14 to 20 years with average of 16.43 (SD=2.07). The means and standard deviations for general training details of the gymnasts are summarized in Table 3.1, 3.2, and 3.3.

Table 3.1. General Training Information (n=10)

	Average	SD	Max.	Min.
Age (yrs)	15.80	2.04	20	13
Years in current level	1.10	0.32	2	1
Years in RG	5.60	0.84	7	4
Training hours/ wk	8.70	4.66	35	0
Training squad size	10.20	4.83	20	2
Number of Coaches	1.40	0.70	3	1

Table 3.2. General Training Information for Level 5-6 gymnasts (n=3).

	Average	SD	Max.	Min.
Age (yrs)	14.33	1.15	15	13
Years in current level	1.33	0.58	2	1
Years in RG	5.33	1.14	6	4
Training hours/ wk	6.75	2.78	14	0
Training squad size	13.00	8.19	20	4
Number of Coaches	2.00	1.00	3	1

Table 3.3. General Training Information for Level 7-9 gymnasts (n=7).

	Average	SD	Max.	Min.
Age (yrs)	16.43	2.07	20	14
Years in current level	1	0	1	1
Years in RG	5.71	0.76	7	5
Training hours/ wk	9.17	4.42	35	0
Training squad size	9.0	2.65	10	3
Number of Coaches	1.14	0.38	2	1

Dominant hand, leg and, pivoting direction of the gymnasts are summarized in Table 3.4. The majority of the gymnasts were right-hand dominant, right-leg dominant, and right-pivot direction dominant, 9 of the total 10 (90%), 7 of the total 10 (70%), and 9 of the total 10 (90%) respectively.

Table 3.4. Dominant hand, leg, and pivoting direction (n=10).

	Right	Left	Both
Dominant Hand	9	0	1
Dominant Leg	7	3	0
Dominant Pivot	9	1	0

3.2 Injury Information

From the sample (n=10), a total of 38 injuries for the 6-month survey period were reported, with an average of 3.8 injuries per gymnast. Level 5-6 gymnasts (n=3) sustained 10 injuries (average 3.3 injuries/gymnast) and Level 7-9 (n=7) sustained 28 injuries (average 4 injuries/gymnast). The Level 5-6 gymnasts sustained only short-term injuries (injuries had restricted/limited training for less than a week). In contrast, the Level 7-9 gymnasts sustained several injuries that restricted/limited for more than one week. Of the 28 injuries sustained by the Level 7-9 gymnasts, six injuries restricted/limited training for two weeks, three injuries restricted/limited training for three weeks, one injury restricted/limited training for four weeks, one injury restricted/limited training for nine weeks, one injury restricted/limited training for 11 weeks, and one injury restricted/limited training for the full 26 weeks survey period (see Figure 3.1).

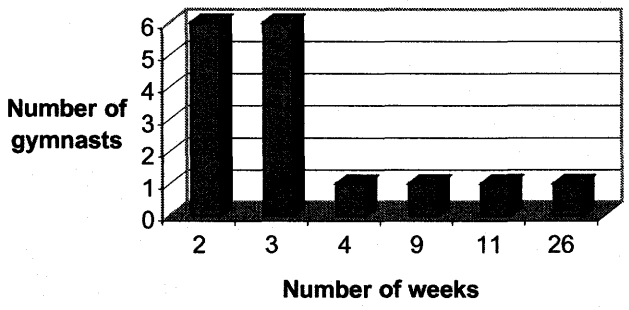

Figure 3.1. Number of weeks an injury restricted training.

No gymnast was injury-free for the entire six-month period. Nine of the total 10 participants (90%) reported two or more injuries and 4 of the

total 10 participants (40%) reported five or more injuries for the six-month survey period (see Figure 3.2)

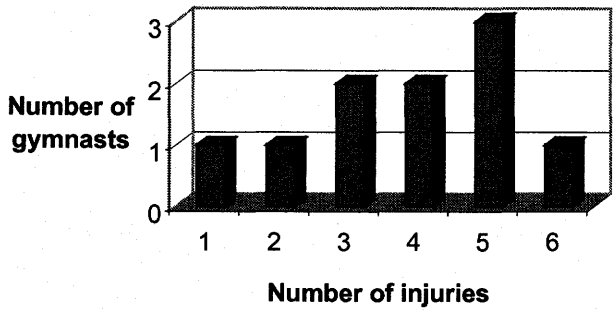

Figure 3.2. Number of total injuries each gymnast sustained.

The injury incidence rate for the Level 5-6 gymnasts was higher than the Level 7-9 gymnasts. The 10 gymnasts reported a total of 2225.5 training hours (overall injury incidence rate of 1.71 injuries/100 hours). The Level 5-6 (n = 3) gymnasts accumulated a total of 528.5 training hours and reported 10 injuries (an injury incidence rate of 1.89 injuries/100 hours). The Level 7-9 (n = 7) gymnasts accumulated a total of 1697 training hours and reported 28 injuries (1.65 injuries/100 hours). Once again, due to the low subject numbers, one must be cautious when interpreting these results.

3.2.1 Body part injured

Table 3.5 illustrates the distribution of injuries per body part. The most common location for injuries was the leg (ankle, shin, calf, hamstring), which accounted for 25 of the total 38 injuries (65.79%). This

was followed by the pelvis, 5 of the total 38 injuries (13.16%), trunk, 4 of the total 38 injuries (10.53%), head, 2 of the total 38 injuries (5.26%), and arm, 2 of the total 38 injuries (5.26%). The Level 5-6 gymnasts reported the leg, 5 of the total 10 injuries (50%), to be the most frequent injury location, followed by the head, 2 of the total 10 injuries (20%), trunk, 1 of the total 10 (10%), arm, 1 of the total 10 injuries (10%), and pelvis, 1 of the total 10 injuries (10%). The Level 7-9 gymnasts reported the most frequent injury location as the leg, 20 of the total 28 injuries (71.43%), followed by the pelvis, 4 of the total 28 injuries (14.29%), trunk, 3 of the total 28 injuries (10.71%), and the arms, 1 of the total 28 injuries (3.57%).

Table 3.5 Anatomical distributions of injuries.

Body Part	All		L5-6 (n=3)		L7-9 (n=7)	
	N	%	N	%	N	%
Head	2	5.26	2	20.00	0	0.00
Spine	0	0.00	0	0.00	0	0.00
Trunk	4	10.53	1	10.00	3	10.71
Arm	2	5.26	1	10.00	1	3.57
Pelvis	5	13.16	1	10.00	4	14.29
Leg	25	65.79	5	50.00	20	71.43
Total	38		10		28	

3.2.2 Chronic versus Acute Injuries

Table 3.6 details the nature of injuries sustained by the subjects. Chronic injuries were the most prevalent injury sustained, representing 24 of the total 38 injuries (63.16%). For the Level 5-6 gymnasts, sudden onset injuries were the most frequent injury type representing 7 of the

total 10 injuries (70%). Level 7-9 gymnasts sustained more chronic injuries, representing 21 of the total 28 injuries (75.00%) of the total number of injuries. This warrants further investigation with larger numbers.

Table 3.6. Distribution of the nature of injuries.

Nature of injury	All		L5-6 (n=3)		L7-9 (n=7)	
	N	%	N	%	N	%
Acute	14	36.84	7	70.00	7	25.00
Chronic	24	63.16	3	30.00	21	75.00
Total	38		10		28	

3.2.3 Side of injury

Injuries were classified as being located on either the right or left side of the body. The majority of injuries, 19 of the total 30 injuries (63.3%) occurred on the right side of the body. Both groups sustained approximately 62% of their total injuries on the right side of the body, with the Level 5-6 gymnasts, 5 of the total 8 (62.5%) and the Level 7-9 gymnasts sustaining 14 of the total 30 injuries (63.6%) (see Table 3.7).

Table 3.7. Side of body injured.

Side	All		L5-6		L7-9	
	N	%	N	%	N	%
Right	19	63.33	5	62.50	14	63.64
Left	11	36.67	3	37.50	8	36.36
Total	30		8		22	
No response	8					

Controlling for the gymnasts side of dominance, it was found that 17 of the total 29 injuries (58.62%) occurred on the dominant side. Five in the total 8 injuries (62.50%) for Level 5-6 gymnasts and 12 of the total 21 injuries (57.14%) for Level 7-9 gymnasts occurred on the gymnasts' dominant side (see Table 3.8).

Table 3.8. Distribution of injuries relative to dominant side

	All		L5-6		L7-9	
	N	%	N	%	N	%
Dominant	17	58.62	5	62.50	12	57.14
Non-Dominant	12	41.38	3	37.50	9	42.86
Total	29		8		21	
No response	9					

3.2.4 Classification of Injury

Table 3.9 details the frequency of each injury classification. Muscle strains were the most frequent occurring type of injury, 24 of the total 38 injuries (62.16%), followed by sprains, 5 of the total 38 injuries (13.16%). More specifically, the most common type of injury reported by Level 5-6 gymnasts was muscle strains, 5 of the total 10 injuries (50%), followed by contusions, 2 of the total 10 injuries (20%), and rope and carpet burns, 2 of the total 10 injuries (20%). Level 7-9 gymnasts predominately sustained muscle strains, 19 of the total 28 injuries (67.86%), followed by sprains, 5 of the total 28 injuries (17.86%).

Table 3.9. Injury Classification

Classification	All		L5-6 (n=3)		L7-9 (n=7)	
	N	%	N	%	N	%
Shin Splints	2	5.26	0	0.00	2	7.14
Muscle Strain	24	62.16	5	50.00	19	67.86
Sprain	5	13.16	0	0.00	5	17.86
Tendonitis	1	2.63	0	0.00	1	3.57
Bruise	2	5.26	2	20.00	0	0.00
Rope/carpet burn	2	5.26	2	20.00	0	0.00
Unknown	1	2.63	0		1	3.57
Other	1	2.63	1	10.00	0	0.00
Total	38		10		28	

3.2.5 Injuries during training sessions versus injuries during competitions

The time of sustaining an injury was documented for 32 injuries, with 29 of the total 32 injuries (90.63%) sustained during a training session. Level 5-6 gymnasts sustained all of their injuries (n=10) during a training session, while 19 of the total 22 injuries (86.36%) of the Level 7-9 injuries occurred during a training session.

3.2.6 Time period during training sessions when injury occurred

Of the 23 respondents, 9 injuries occurred during warm-up, (39.13%). This was followed by injuries sustained in the first-quarter, 4 of the total 23 (17.39%) and the last-quarter of training, 4 of the total 23 (17.39%). Level 5-6 gymnasts had an equal distribution, with 3 of the total 6 (50%) of injuries occurring during warm-up and 3 of the total 6 (50%) during the last quarter. Level 7-9 gymnasts reported the majority

of their injuries during warm-up, 6 of the total 17 (35.29%), followed by 4 of the total 17 (23.53%) during the first quarter.

3.2.7 Length of training

For all the gymnasts, when reported, 10 of the total 23 injuries (43.48%) injuries were sustained when the training session was three hours in duration. Level 5-6 gymnasts sustained 3 injuries (37.5%) in each of three hour and four hour training sessions. Training sessions three hours in length produced the greater number of injuries for Level 7-9 gymnasts, 7 of the total 15 injuries (46.67%).

Table 3.10. Timing of injuries.

Training hours	All		L5-6		L7-9	
	N	%	N	%	N	%
2	5	21.74	2	25.00	3	20.00
3	10	43.48	3	37.50	7	46.67
4	5	21.74	3	37.50	2	13.33
5	3	13.04	0	0.00	3	20.00
Total	23		8		15	
No response	15					

3.2.8 Skill difficulty when injured

Of those subjects that indicated the difficulty of the skill when injured, 11 of the total 21 injuries (52.38%) occurred while the gymnasts were performing basic skills, while 7 of the total 21 (33.33%) injuries occurred during moderate difficulty skills and only 3 of the total 21 injuries (14.29%) occurred when performing difficult skills. Performing a basic skill when injured was most prevalent for Level 5-6 gymnasts, 6 of

the total 7 injuries (85.71%). Level 7-9 gymnasts sustained more injuries performing skills of moderate difficulty, 6 of the total 14 injuries (42.86%) (see Table 3.11). Gymnasts were not getting injured while performing difficult skills.

Table 3.11. Skill difficulty when injured.

Skill Difficulty	All		L5-6		L7-9	
	N	%	N	%	N	%
Basic	11	52.38	6	85.71	5	35.71
Moderate	7	33.33	1	14.29	6	42.86
Difficult	3	14.29	0	0.00	3	21.43
Total	21		7		14	
No response	17					

3.2.9 Injuries occurring during routine training versus during skill training

Table 3.12 details the various activities performed when injuries were sustained. The category "injured while practicing skills" was the most common for the whole group, 13 of the total 25 injuries (52%), followed by practicing a routine, 10 of the total 25 injuries (40%). Level 5-6 gymnasts sustained most of their injuries while practicing a skill, 5 of the total 8 injuries (62.5%), followed by practicing a routine, 2 of the total 8 injuries (25%). The number of injuries sustained while practicing a routine and practicing a skill were found to be equal for the Level 7-9 gymnasts, 8 of the total 17 injuries (47.06%).

Table 3.12. Activity when injured

Activity	All		L5-6		L7-9	
	N	%	N	%	N	%
During skill training	13	52.00	5	62.50	8	47.06
During routine training	10	40.00	2	25.00	8	47.06
Aerobic warm-up	2	8.00	1	12.50	1	5.08
Total	25		8		17	
No response	13					

3.2.10 Gymnasts' Perceived cause of injury

This investigation revealed that there was an array of perceived causes of injuries. The majority of injuries for the whole group were perceived by the gymnast to be the result of overuse, 8 of the total 30 injuries (26.67%) (see Table 3.13). This was followed closely by fatigue, 7 of the total 30 (23.33%). Loss of balance was the perceived primary cause of injury, 3 of the total 8 (37.5%) for Level 5-6 gymnasts, while overuse was the perceived primary cause of injury, 7 of the total 22 (31.82%) for Level 7-9 gymnasts.

Table 3.13. Perceived cause of injury as reported in the questionnaire.

Cause	All		L5-6		L7-9	
	N	%	N	%	N	%
Contact with Apparatus	1	3.33	1	12.50	0	0.00
Matting	1	3.33	0	0.00	1	4.55
Loss of Balance	4	13.33	3	37.50	1	4.55
Overuse	8	26.67	1	12.50	7	31.82
Previous injury	3	10.00	1	12.50	2	9.09
Attempting skill beyond	2	6.66	0	0.00	2	9.09
Fatigue	7	23.33	2	25.00	5	22.72
Muscle imbalance	1	3.33	0	0.00	1	4.55
Unknown	3	10.00	0	0.00	3	13.64
Total	30		8		22	
No response	8					

3.2.11 Pain Level

Overall, the level of pain associated with the injury was rated to be 4.97 out of 10 (0.7-9.3). There was very little difference in the level of perceived pain associated with the injury between the two groups. More specifically, Level 5-6 gymnasts rated their level of pain to be on average 5.02, while Level 7-9 gymnasts rated their level of pain to be on average 4.93.

3.2.12 Missed and modified training sessions

Of the 38 injuries sustained by gymnasts during training, only three resulted in the gymnast terminating the training session. Level 5-6 gymnasts sustained two of these injuries and Level 7-9 gymnasts sustained one. Only a small number of injuries (n=3) sustained by the group required the gymnast to miss additional training sessions. Level 5-6 gymnasts sustained two of these injuries and the Level 7-9 gymnasts sustained one.

A total of 28 training days were modified as a result of an injury. Level 5-6 gymnasts modified a total of 11 days, while Level 7-9 gymnasts modified a total of 17 days.

3.2.13 Subjective health status of the gymnast as reported weekly

Of the 38 injuries sustained, 23 injuries (60.53%) occurred in a week in which the gymnasts were feeling fatigued. Level 7-9 gymnasts commonly reported this, with 18 the total 28 injuries (64.29%) being sustained when feeling fatigued. Level 5-6 gymnasts sustained 5 of the 10 injuries (50%) while fatigued.

Training while feeling ill was not related to the prevalence of injury as only one injury was sustained when a gymnast was feeling unwell.

3.3 General Discussion

This study endeavored to document the nature, etiology, severity, prevalence and incidence rate of injuries sustained in Australian club-level rhythmic gymnasts. Due to the low subject number, inferential statistics were not calculated.

3.3.1 General Information

The comparison of the Level 5-6 gymnasts and Level 7-9 gymnasts illustrated minor differences between general training regimes. The data indicated there was a tendency for the higher-level gymnasts to be older and to train more hours a week than the lower-level gymnasts (9.17 hours per week versus 6.75 hours per week). The rhythmic gymnasts in this study trained approximately one-quarter of the hours (8.70 hours per week) an elite artistic gymnast would train (30-40 hours per week) and approximately half the hours of an Australian club-level artistic gymnast (16.8 hours per week) (Caine et al., 1996; Kolt & Kirkby, 1999).

3.3.2 Injury Information

The 10 gymnasts in this study trained a total of 2225.5 hours and sustained 38 injuries. All gymnasts sustained at least one injury during the study. This was not anticipated, given the short sampling period.

Interestingly, a large percentage of the gymnasts sustained multiple injuries, with 90% sustaining two or more injuries and 40% sustaining five or more injuries during the six-month study period.

As a group, the gymnasts averaged 3.8 injuries per gymnast, with Level 5-6 gymnast averaged 3.3 injuries per gymnast and Level 7-9 gymnasts averaged 4 injuries per gymnast. With no previous research undertaken in the area of rhythmic gymnasts, it is unknown if the prevalence of injury sustained per gymnast yielded in this investigation was representative of the larger population of rhythmic gymnasts. Compared with studies on Australian club-level artistic gymnasts, this group of rhythmic gymnasts sustained more injuries. Kolt and Kirkby (1999) found that Australian subelite (club-level) gymnasts sustained 3.3 injuries per gymnast in a 12-month period. Due to the limitations of the present study, it is difficult to explain the higher prevalence of injuries in this sample of rhythmic gymnasts. Rhythmic gymnasts were in competition season for three of the six months comprising the study.

As the amount of training that gymnasts undertake is dependent on their level, it was important to record the incidence rate of injury in relation to number of hours trained per week. As a whole group, the present sample of rhythmic gymnasts sustained 1.71 injuries per 100 hours. The comparison of the two levels showed the Level 5-6 gymnasts sustained more injuries per 100 hours than the Level 7-9 gymnasts, 1.89 injuries per 100 hours compared to 1.65 injuries per 100 hours

respectively. The higher incidence rate of injuries in Level 5-6 gymnasts suggests that they may be at a greater risk of injury. Kolt and Kirkby (1999) stated that the higher incidence rate of injuries in their study may have resulted from the gymnasts attempting skills beyond their capabilities. This trend was not evident in the present study with the lower-level gymnasts sustaining more injuries while performing basic skills.

The results suggested that this sample of rhythmic gymnasts sustained more injuries per 100 hours compared to investigations on artistic gymnasts. The Australian artistic club-level gymnasts sustained 0.41 injuries per 100 hours (Kolt & Kirkby, 1999), while USA gymnasts sustained 0.33 injuries per 100 hours (Caine et al., 1989). The findings of Artistic Gymnastics studies are much lower than the 1.71 injuries per 100 hours yielded in the present study. A major limitation of the current study was the small sample size of rhythmic gymnasts (n=10) compared to the large sample size studies conducted by Caine et al. (1989) (n= 50) and Kolt and Kirkby (1999) (n=132). All studies used a similar definition of injury, "resulting in a modification or restriction in training", and a weekly reporting system.

3.3.3 Body part injured

The majority of the injuries sustained were to the lower extremities (65.79%), showing a trend to support hypothesis 2. This is consistent

with previous Artistic Gymnastics and ballet studies (Caine & Lindner, 1988; Caine et al., 1989; Schafle et al., 1990; Kadel, 1992; Dixon & Fricker, 1993; Kolt & Kirkby, 1999). Indeed, the high prevalence of injuries sustained to the lower extremities could be attributed to the large number of leaps and jumps executed by rhythmic gymnasts during training sessions. Furthermore, as rhythmic gymnasts have minimal weight-bear on their upper extremities, minimal injuries were sustained in this area.

It was anticipated that the trunk (upper and lower back) would sustain the second highest number of injuries, as found in previous ballet studies (Schafle et al., 1990; Kadel, 1992). The results of the present study, however, found the pelvic girdle (including the hip joint) (13.16%) to be the second most frequent injury site. The high prevalence of these injuries for the whole group was largely due to the Level 7-9. The author could not explain the high prevalence of pelvic girdle (including hip joint) injuries in these higher-level rhythmic gymnasts. Krasnow et al. (1999), however, found that ballet dancers and artistic gymnasts sustained more hip injuries than the normal female population. It is suggested that the nature of the sport may expose the rhythmic gymnasts to a higher risk of hip joint and pelvic girdle injuries than the other two sports.

3.3.4 Chronic versus acute injuries

It was anticipated that the rhythmic gymnasts would sustain a larger number of acute injuries than chronic injuries. It was thought, however, that the proportion of acute versus chronic injuries in rhythmic gymnasts would be consistent with the proportion sustained by ballet dancers as opposed to artistic gymnasts. In contrast, the rhythmic gymnasts in this study sustained more chronic than acute injuries, (63.16%). The high incidence rate of chronic injuries sustained by the Level 7-9 gymnasts skewed the number of chronic injuries seen in this group of gymnasts. The Level 7-9 gymnasts sustained 75% chronic injuries while the Level 4-6 gymnasts only sustained 30% chronic injuries. The author was unable to ascertain why there were a large proportion of chronic injuries in the Level 7-9 gymnasts. As the Level 7-9 gymnasts were post-pubertal, it is doubtful that the high rate of chronic injuries was related to growth tissue, as suggested by Caine and Lindner (1990) in their study of artistic gymnasts. Repetitive stress has been used to justify the high proportion of chronic injuries in ballet dancers. This could be similar for high-level rhythmic gymnasts. In the pursuit of perfection, the higher-level rhythmic gymnasts undergo a high volume of repetitive stress without adequate recovery time and, thereby, develop a large number of chronic injuries.

3.3.5 Side of Injury

The rhythmic gymnasts in this study were predominately right-side dominant (e.g., they prefer using their right leg, right arm, and pivoting to the right). Although it is required that gymnasts use both sides of the body equally, they typically favour one side. As the gymnasts in the current investigation were predominantly right-side dominant, it was anticipated that more injuries would be sustained on the right side, due to overuse. This was the trend, with more injuries occurring on the right side for the group (63.33%) and the Level 7-9 gymnasts (63.6%).

Controlling for the gymnasts' dominant side, reported injuries were primarily sustained on the gymnasts' dominant side. However, this trend was not strong. There were more injuries on the gymnasts' dominant side for the whole group (58.62%) and the Level 7-9 gymnasts (57.1%). As the gymnasts are favoring one side of the body, it is suspected that the dominant side is being overused and, thereby, making the gymnasts more susceptible to injury.

3.3.6 Classification of injury

In contrast to previous Artistic Gymnastics and ballet studies (Pettrone & Ricciardelli, 1987; Caine & Lindner, 1989; Howse & Hancock, 1992; Kolt & Kirkby, 1999), strains as opposed to sprains were more frequently reported by the cohort of rhythmic gymnasts in the present study. More specifically, the whole group sustained 62.16% of

all injuries as strains. Level 5-6 sustained 50% and Level 7-9 sustained 67.86% of injuries as strains. The author cannot speculate on the higher prevalence of strains.

Disparity exists between the injuries sustained within the two groups comprising the investigation. Other than strains, the Levels 5-6 gymnasts restricted their training when sustaining a rope/carpet burn or bruise. Level 7-9 gymnasts reported that more serious injuries restricted their training, such as shin splints, sprains, and tendonitis. These results suggest that the level of gymnasts differ in their perceived seriousness and severity of their injury.

3.3.7. Training session versus competition injuries

Baxter-Jones et al. (1993) suggested that artistic gymnasts sustain more injuries during training sessions than during competition. Similar results were yielded in the current study, with 90.63% of all injuries occurring during training sessions. Despite the gymnasts in the present study being in competition season for three months, they only participated in two to four competitions. This may explain the disproportionate number of injuries sustained by participants during training sessions.

3.3.8. Time during training when injury occurred

The results of the present study revealed that diversity exists in the timing of injuries during training sessions. Caine and Lindner (1996) found that artistic gymnasts sustained the majority of their injuries during the last-quarter of a training session. This current study found only a small proportion of injuries occurred during this time (17.39%). In contrast to Caine and Lindner's (1996) investigation, the present study found that most injuries were sustained or began during warm-up (39.13%), thus the data did not show a trend to support hypothesis 3. Indeed, Caine et al. (1989) suggested that injuries sustained during the first hour of training resulted from an insufficient warm-up regime. Without knowing what gymnasts are doing during their warm-up, it is difficult to explain the large number of injuries sustained during this period. The large number of injuries sustained during warm-up could be the result of: beginning training with a previous injury, performing inappropriate activities, or a lack of concentration.

For the majority of gymnasts participating in this investigation, training sessions lasted three hours in duration. The majority of injuries, therefore, occurred when training sessions were three hours in duration, thus partially supporting hypothesis 4. The author speculates that more injuries occurred during three-hour training sessions as a result of few breaks being given compared to longer training sessions in which coaches allow gymnasts more breaks. A positive correlation has been

found to exist between the prevalence of injuries and the duration of training in artistic gymnasts (Pettrone & Ricciardelli, 1987). When taking into account the above findings (a large proportion of injuries being sustained during warm-up and a small proportion during the last quarter), it is difficult to suggest injuries are the result of fatigue.

3.3.9 Skill Difficulty when Injured

This current study found that a large proportion of injuries were sustained while performing basic skills (52.38%), as hypothesized (hypothesis 5). This was greater than the number of injuries sustained while executing difficult skills. Lindner and Caine (1990) found that 35.59% of all Artistic Gymnastics injuries occurred while performing basic skills. The club-level rhythmic gymnasts sustained the majority of their injuries while performing basic skills (85.71%). Ideally, basic skills should not require the same level of attentiveness as difficult skills. It is possible that gymnasts perceive these skills as being too basic and, therefore, are not concentrating to the same level as for more difficult skills. Alternatively, the gymnasts are performing numerous repetitions of the skill and it is this repetition that is leading to injury. Level 7-9 gymnasts, on the other hand, sustained the majority of their injuries while performing skills of moderate difficulty (42.86%). Kolt and Kirkby (1999) suggested that artistic level gymnasts sustained injuries as a result of striving to achieve skills beyond their physical ability. Level 7-9

gymnasts could be susceptible to this as they try to execute requirements they have not prepared for adequately.

3.3.10. Routines versus skill training

Sustaining an injury while practicing a skill was more likely than sustaining an injury while performing a routine (52%). Caine et al. (1996) found that elite-level artistic gymnasts perform between 700 and 1300 skills in any given training session. With a large percentage of time in a training session devoted to practicing skills, it was not surprising to find that the majority of injuries occurred during this time.

3.3.11. Perceived Cause of Injury

Based on gymnasts' perception of why they sustained their injury, overuse played the biggest role (26.67%) followed by fatigue (23.33%). These results are difficult to explain given that more injuries were sustained in warm-up than any other quarter of training. The fact that these gymnasts trained after school without a break may explain why they were feeling fatigued.

3.3.12. Pain Level

A wide range of pain was associated with the gymnasts' injuries (0.7-9.3). One would not suspect that injuries of low pain level would cause gymnasts to modify or restrict their training. When comparing the result

achieved in the two groups, no one group skewed the results. Both groups reported the same range of pain levels and very little difference in their mean pain level (Level 5-6 gymnasts 5.02 and Level 7-9 gymnasts 4.93).

3.3.13 Missed and modified time

The gymnasts in this study did not always indicate on their weekly injury form the time that their injuries restricted training. The collective results suggest that this sample of gymnasts rarely missed training through injury. Instead, they would typically continue to train, but modified their training program. Three injuries required the gymnast to miss the remainder of a training session and three injuries required the gymnast to miss additional days of training. It is difficult to ascertain from this study whether this form of injury management is better than complete cession of training. Macintyre and Joy (2000) suggested that if an injury was not treated sufficiently, incorrect techniques would develop to compensate for the original injury. This compensation in alternative movement pattern places a strain on other muscles and joints, which, in turn, results in further injury and the development of a chronic injury. With the high incidence rate of injury and the long-term effect of these injuries, continuing to train with an injury might not be beneficial for the long-term health of gymnast.

Chapter Four

CONCLUSIONS

The current study provides an important preliminary investigation concerning the prevalence and incidence rate of injuries in Australian club-level rhythmic gymnasts. While many of the findings of the present study are consistent with the results achieved in Artistic Gymnastics and ballet studies, some results were particularly pertinent to Rhythmic Gymnastics.

A major finding of the current investigation was the substantially high number of injuries in relation to practice time. The majority of these injuries were sustained on the lower extremities. Rhythmic gymnasts perform a large number of leaps and jumps during a training session, which exposes their lower extremities to repetitive forces. The investigation found that gymnast/s perceived cause of injury was reported to be from fatigue and overuse. These findings are consistent with the considerable number of chronic injuries sustained by rhythmic gymnasts in the current investigation. Indeed, the high number of chronic injuries could be attributed to the minimal number of training sessions missed by gymnasts when injured. Failing to provide these gymnasts with sufficient time to heal may be

exposing these injury sites to repeated stress, which, in turn, could lead to microtrauma of the tissue.

The participants in the current study were also one-side dominant, which increased the gymnasts' exposure to injury on the dominant side. Another notable finding was the absence of serious injuries, with no fractures, stress fractures, or dislocations being reported. Indeed, the primary type of injury reported by the gymnasts in this investigation was strains. The results of the present study also revealed that the majority of injuries occurred during a training session versus during competition and, more specifically, while practicing basic skills. Gymnasts sustained more injuries during warm-up than during any other segment of training. Given the aforementioned findings, the author defined club-level rhythmic gymnasts at high risk of injury as being: (1) at a high-level of club-level gymnastics, (2) warming up, (3) training three hours in one session, and (4) training when fatigued.

It is acknowledged that there are limitations with the present study. There are limitations associated with using questionnaires as a means of data collection. The questionnaire contained closed-ended questions, which often reduces the freedom of the response generated. Another limitation is that the small cohort of gymnasts used in this investigation limits the ability to generalize the results to Australian club-level gymnasts as a whole. Furthermore, the

reluctance of Australian club-level and elite-level rhythmic gymnastics coaches to participant prevented numerous gymnasts from participating in the study.

As a small sample of club-level rhythmic gymnasts were utilized in the present study, caution should be exercised in generalizing the results for the Rhythmic Gymnastics community and elite rhythmic gymnasts. The small sample and short time frame of this investigation might not have depicted the true prevalence and incidence rate of Rhythmic Gymnastics injuries. Caution must be exercised when interpreting any disparity between Artistic Gymnastics and ballet investigations and the present study, given that these differences might reflect the dissimilarity in the nature of the sports. Furthermore, the findings of this study may only be pertinent to this sample of rhythmic gymnasts.

Despite these limitations, the present data initiates research into the prevalence and nature of injuries for club-level rhythmic gymnasts. Future studies should use a larger cohort of rhythmic gymnasts, focus on the techniques rhythmic gymnasts are using to perform skills, and the effects that these techniques have on the musculoskeletal system.

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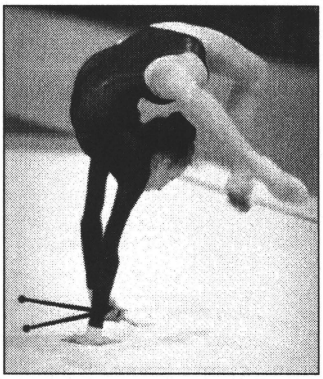
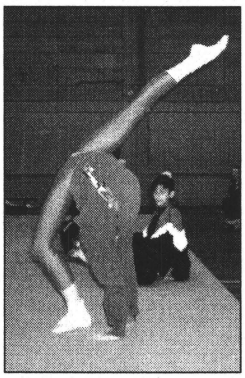
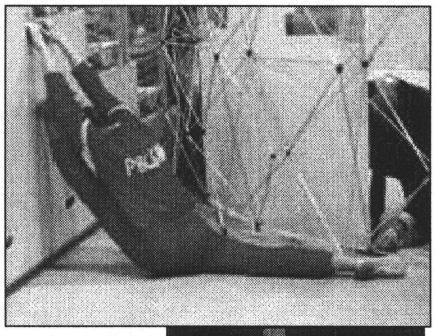
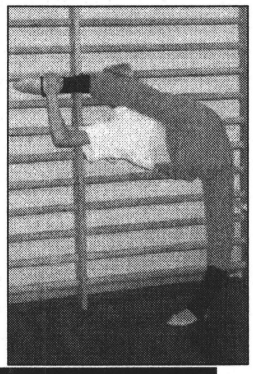
APPENDIX A

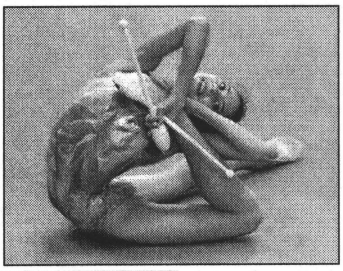
Rhythmic Extreme Positions

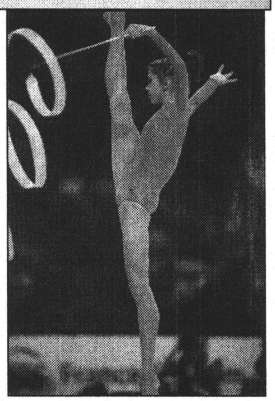


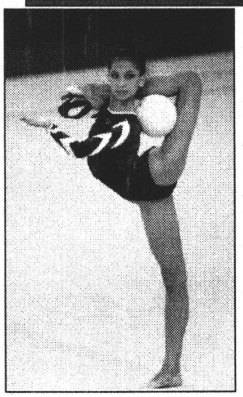


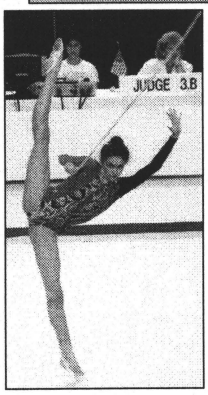












APPENDIX B

COPY

UNIVERSITY ADVISORY COMMITTEE
ON ETHICS IN BEHAVIOURAL SCIENCE RESEARCH

NAME: K. Russell (A. Hobson)
College of Kinesiology

BSC#: 2000-59

DATE: May 15, 2000

The University Advisory Committee on Ethics in Behavioural Science Research has reviewed the Application for Ethics Approval for your study "Epidemiological Study of Injuries in Rhythmic Gymnastics" (00-59).

1. Your study has been APPROVED.

2. Any significant changes to your proposed study should be reported to the Chair for Committee consideration in advance of its implementation.

3. The term of this approval is for 5 years.

I wish you a successful and informative study.

Valerie Thompson, Chair
University Advisory Committee
on Ethics in Behavioural Science Research

VT/bjk

Office of Research Services, Ethics Committees, University of Saskatchewan
Kirk Hall Room 207, 117 Science Place, Saskatoon SK S7N 5C8 CANADA
Telephone: (306) 966-4053 Facsimile: (306) 966-8597 http://www.usask.ca/research/

APPENDIX C

UNIVERSITY OF SASKATCHEWAN

College of Kinesiology

Coaches Consent Form

My Name is Anita Hobson. I am currently doing my Master's degree at the University of Saskatchewan, Canada. I am also a Rhythmic Gymnastics coach and judge (QLD judging coordinator) in Queensland.

For my thesis I am conducting an epidemiological investigation of the nature, etiology, severity and rates of injuries sustained in Rhythmic Gymnastics. This study will be the first formal research of injuries in Australian Rhythmic gymnastics. This information will be for the benefit of coaches, athletes, administrators and sports medicine professionals.

Participants in this study will involve a sample of Australian gymnasts from Levels 5-10, Stages 3 and 4, Junior Elite and Senior Elite.

As I coach I would like to have your consent for gymnasts in your club to be involved in the study. Below outlines details of the study. If you have any questions, please feel free to contact me. This for must be signed and forward back to Robyn Pride.

Procedures

Part 1 consists of 2 questionnaires: General Information questionnaire and a retrospective questionnaire, which tracks injuries sustained in the last 6 months. This will be completed at the AIS Camp.

Part 2 of the study consists of you completing a weekly injury questionnaire for a six-month period. This will commence the week of the AIS Camp.

An assistant/apprentice coaches or parent will collect the injury report forms from their gymnasts weekly and send them to the investigator. To ensure **confidentiality**, every gymnast has an identification code.

Withdrawal

Your gymnasts are free to withdraw from the study at anytime and this withdrawal will not affect their eligibility to represent their state or country. If they withdraw, their data will be deleted from the study.

Confidentiality and Anonymity

Gymnasts will be ensured complete confidentiality and anonymity. They will be given a code and will be recognized by this code only. The gymnasts will hand their weekly forms to the coach/parent in a seal envelope to ensure confidentiality of their injuries. Personal details will not be given to you the coach, state gymnastics association or Gymnastics Australia.

Uses of Data Collected

Data that is collected is for the exclusive use of the researcher. If an article is published, no personal data will be used, instead only average data will be reported.

Contact details

If you have any questions with regard to the study, you can contact Linda Pettit, Robyn Pride or Margaret Lanz at Gymnastics Australia or myself.

Parental Consent

If the gymnast is under the age of 18, written consent of the parent(s) or guardian(s) or caregivers must be obtained.

Debriefing and Feedback

At the conclusion of the study, gymnasts will receive a summary of everything they reported during the study and a report on the study. If they then have any questions, I will be happy to answer them.

Researchers Details

Anita Hobson BScApp HMS
63 Faringdon St
Robertson, Q 4109
ph/fax: 07 3345 5522
email: ahobs@logicworld.com.au

Regards,

Anita Hobson

Gymnasts' names:

_____

_____

_____ _____

Coach's signature Date

APPENDIX D

University of Saskatchewan
College of Kinesiology

Parental Consent Form

1. **Title of Study:**
   Epidemiological Study of Injuries in Rhythmic Gymnastics

2. **Researcher:**
   Anita Hobson BScApp HMS (ExMan)
   College of Kinesiology , University of Saskatchewan Canada
   Ph: (306) 966 2604 email: @mail.usask.ca

3. **Purpose:**
   To investigate the nature, etiology, severity and rates of injuries sustained in Rhythmic gymnastics.

4. **Benefits of the study:**
   This study will be first survey injuries in Australian Rhythmic gymnastics. This information will be beneficial for coaches, athletes, administrators personal and sports medicine professionals.

5. **Procedures:**
   Part 1 consists of 2 questionnaires: the General Information questionnaire and the retrospective questionnaire, which tracks injuries sustained in the last 6 months.

   Part 2 of the study consists of you completing a weekly injury questionnaire for a six-month period.

   An assistant/apprentice coaches or parent will collect the weekly injury report forms from their gymnasts weekly and send them to the investigator. To ensure **confidentiality**, the gymnasts will hand their forms in to the coach/parent in a **sealed** envelope.

6. **Withdrawal**
   You are free to withdraw from the study at anytime. This withdrawal will not affect your eligibility to represent your state or country. If you withdraw, your data will be deleted from the study.

7. **Confidentiality and Anonymity**

You will be ensured complete confidentiality and anonymity. You will be given a code and you will be recognized by this code only. You will hand your weekly forms to the coach/parent in a seal envelope to ensure confidentiality of your injuries. Personal details will not be given to your coach(s), state gymnastics association or Gymnastics Australia.

8. **Uses of Data Collected**

Data that is collected is for the exclusive use of the researcher. If an article is published, no personal data will be used, instead only average data will be reported.

9. **Contact details**

If you have any questions with regard to the study or your rights as a participant in the research study, you can contact Linda Pettit, Robyn Pride or Margaret Lanz at Gymnastics Australia or the researcher.

10. **Consent**

If you are under the age of 18, written consent of your parent(s) or guardian(s) or caregivers must be obtained. A record of your consent will be kept in your records.

11. **Debriefing and Feedback**

At the conclusion of the study, you will receive a summary of everything you reported during the study and a report on the study. If you then have any questions, the researcher will happy answer them.

12. **University of Saskatchewan**

If you need to contact the Office of Research at the University of Saskatchewan regarding your rights as a participant in the study, the details are as follows:

Office of Research Services, Ethics Committee, U of S
Kirk Hall, Room 207, 117 Science Place
Saskatoon, Saskatchewan
S7N 5C8
Canada
Tel: 306 966 4053
Fax: 306 966 8597

_____ _____

Participants signature Parent's signature (if younger than 18)

APPENDIX E

UNIVERSITY OF SASKATCHEWAN RHYTHMIC GYMNASTICS RESEARCH PROJECT

Id: _____

General Information

Name: _____ Club: _____

Address: _____

Email: _____ Phone Number: _____

Age _____ Current Level in rhythmic _____

Number of years in rhythmic _____ Number of years at this current level _____

Is rhythmic the only sport you participate in? Yes No

If No, what other sports do you participate in? _____

What is your dominant hand? Left Right

What is your dominant leg? Left Right

What is your dominant pivoting direction? Left Right

What is floor surface beneath your mats? e.g. sprung wood, concrete _____

How many gymnasts in your training squad? _____

How many coaches supervise your group? _____

Have you had your first menstrual period? Yes No

If yes, at what age did you reach it? _____

Have you had menstrual irregularity Yes No

Have you had amenorrhea (more than 5 months with no periods) Yes No

What age did your mother have her first menstrual period? _____

What age did your sisters have their first menstrual period? _____

Are you injured right now? Yes No

Details _____

Compete the following table for a typical week. The time I spend on:

	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Training length							
Warm-up							
Stretching (passive)							
Stretching (active)							
Conditioning							
Ballet							

APPENDIX F

University of Saskatchewan Rhythmic Gymnastics Research Project

Injury History - last 6 months

An injury is any event that (1) requires medical attention or (2) restricts gymnastics training or performance.

ID Code: _____

A. Body Part:

Head	Spine (bone)	Trunk (soft tissue)	Arm	Pelvis	Leg	
Head	Neck	Upper Back	Shoulder	Hip Bone	Quadricep	Ankle
Face	Upper	Lower Back	Upper	Hip Joint	Hamstring	Achilles
Dental	Lower	Abdomen	Elbow	Groin	Knee	Foot/Toe
Eye	Sacral/ SI		Forearm		Shin	
			Wrist		Calf	
			Hand/Finger			

B. Nature of Injury:

Developed suddenly Developed over time Always present Reinjury

C. Location of Injury:

Left Right

D. Injury Classification:

Fracture	Stress Fracture	Dislocation	Concussion	Strain (Mus.)	Sprain (Lig.)
Tendonitis	Bruise	Swelling	Rope/carpet Burn	Scrap/Cut	Other: _____

E. Injury during Practice:

Length of Practice was	> 1 hour	> 2 hours	> 3 hours	> 4 hours	> 5 hours	
When injury occurred	Warmup	1st quarter	2nd quarter	3rd quarter	4th quarter	Warmdown
Apparatus	Rope	Hoop	Ball	Club	Ribbon	Other

Skill performing _____

Skill Difficulty (for gymnast)	Basic	Moderate	Difficult	Very Difficult

Injured While	Learning Skill	Practicing Routine	Practicing skill	Ballet training
	Passive stretching	Active stretching	Leap landing	Leap take off
	Playing around	Other_____		

F. Injury during Competition:

When injury occurred	Warmup	1st quarter	2nd quarter	3rd quarter	4th quarter	Warmdown
Apparatus	Rope	Hoop	Ball	Club	Ribbon	Other

Skill performing _____

Skill Difficulty (for gymnast)	Basic	Moderate	Difficult	Very Difficult

Injured While	Practicing skill	Practicing Routine	Competing	Stretching
	Leap landing	Leap take off	Other_____	

G. Cause of Injury

Contact of Apparatus	Matting	Loss of Balance	Insuf. Warm up
Lost Concentration	Fatigue	Overuse	Previous Injury:
Attempting skill beyond ability	Unknown	Other:_____	

H. Pain Level Associated with Injury

Do you have pain? No Yes (if yes, put and X on the line)

Low pain moderate severe

I. Time Missed:

Remainder of Training/Comp. _____ Training days Modified for ___ days

APPENDIX G

University of Saskatchewan Rhythmic Gymnastics Research Project

Weekly Injury Report Form

An injury is any event that (1) requires medical attention or (2) restricts gymnastics training or performance.

ID Code: _____ Date: _____ Hours trained this week: _____

Were you injured this week? Yes No

A. Body Part:

Head	Spine (bone)	Trunk (soft tissue)	Arm	Pelvis	Leg	
Head	Neck	Upper Back	Shoulder	Hip Bone	Quadricep	Ankle
Face	Upper	Lower Back	Upper	Hip Joint	Hamstring	Achilles
Dental	Lower	Abdomen	Elbow	Groin	Knee	Foot/Toe
Eye	Sacral/ SI		Forearm		Shin	
			Wrist		Calf	
			Hand/Finger			

B. Nature of Injury:

Developed suddenly Developed over time Always present Reinjury

C. Location of Injury:

Left Right

D. Injury Classification:

Fracture	Stress Fracture	Dislocation	Concussion	Strain (Mus.)	Sprain (Lig.)
Tendonitis	Bruise	Swelling	Rope/carpet Burn	Scrap/Cut	Other: _____

E. Injury during Practice:

Length of Practice was	> 1 hour	> 2 hours	> 3 hours	> 4 hours	> 5 hours	
When injury occurred	Warmup	1st quarter	2nd quarter	3rd quarter	4th quarter	Warmdown
Apparatus	Rope	Hoop	Ball	Club	Ribbon	Other

Skill performing _____

Skill Difficulty (for gymnast) Basic Moderate Difficult Very Difficult

Injured While	Learning Skill	Practicing Routine	Practicing skill	Ballet training
	Passive stretching	Active stretching	Leap landing	Leap take off
	Playing around	Other_____		

F. Injury during Competition:

When injury occurred	Warmup	1st quarter	2nd quarter	3rd quarter	4th quarter	Warmdown
Apparatus	Rope	Hoop	Ball	Club	Ribbon	Other

Skill performing _____

Skill Difficulty (for gymnast) Basic Moderate Difficult Very Difficult

Injured While	Practicing skill	Practicing Routine	Competing	Stretching
	Leap landing	Leap take off	Other_____	

G. Cause of Injury

Contact of Apparatus	Matting	Loss of Balance	Insuf. Warm up
Lost Concentration	Fatigue	Overuse	Previous Injury:
Attempting skill beyond ability	Unknown	Other:_____	

H. Pain Level Associated with Injury

Do you have pain? No Yes (if yes, put and X on the line)

Low pain moderate severe

I. Time Missed:

Remainder of Training/Comp. _____ Training days Modified for ___ days

Did you feel tired this week? No Yes Were you sick this week? No Yes