University of Nebraska at Omaha
DigitalCommons@UNO

Student Work

4-2000

A Comparison of Lower Back Pain and Injury in Competitive and Non-Competitive Gymnasts

Laura Marie Parks

Follow this and additional works at: https://digitalcommons.unomaha.edu/studentwork

Part of the Health and Physical Education Commons, and the Kinesiology Commons
Please take our feedback survey at: https://unomaha.az1.qualtrics.com/jfe/form/SV_8cchtFmpDyGfBLE

Recommended Citation

Parks, Laura Marie, "A Comparison of Lower Back Pain and Injury in Competitive and Non-Competitive Gymnasts" (2000). *Student Work*. 3053.
https://digitalcommons.unomaha.edu/studentwork/3053

This Thesis is brought to you for free and open access by DigitalCommons@UNO. It has been accepted for inclusion in Student Work by an authorized administrator of DigitalCommons@UNO. For more information, please contact unodigitalcommons@unomaha.edu.

A Comparison of Lower Back Pain and Injury in Competitive and Non-Competitive Gymnasts

A Thesis Presented to the

School of Health, Physical Education, and Recreation

and the

Faculty of the Graduate College

University of Nebraska

In Partial Fulfillment

Of the Requirements for the Degree

Masters of Science

University of Nebraska at Omaha

by

Laura Marie Parks

April 2000

UMI Number: EP73269

All rights reserved

INFORMATION TO ALL USERS
The quality of this reproduction is dependent upon the quality of the copy submitted.

In the unlikely event that the author did not send a complete manuscript
and there are missing pages, these will be noted. Also, if material had to be removed,
a note will indicate the deletion.

UMI
Dissertation Publishing

UMI EP73269

Published by ProQuest LLC (2015). Copyright in the Dissertation held by the Author.

Microform Edition © ProQuest LLC.
All rights reserved. This work is protected against
unauthorized copying under Title 17, United States Code

ProQuest

ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 - 1346

THESIS ACCEPTANCE

Acceptance for the faculty of the Graduate College,
University of Nebraska, in partial fulfillment of the
Requirements for the degree Master of Science,
University of Nebraska at Omaha.

Committee

____

____

____

____

Chairperson______________________________

Date 4-12-2000

ACKNOWLEDGEMENTS

I would like to thank all of the gymnastics coaches who allowed me to conduct this study by handing out questionnaires and to all of the gymnasts who took the time to complete the questionnaires. I would also like to thank my committee members for all of their support and guidance over this last year. Their contributions have helped me complete this study to the best of my ability.

I would especially like to thank my husband and my family for all of their patience and understanding throughout this learning experience.

A special thanks to Dr. Berg, my committee chairperson, for his motivation and direction for this project.

A COMPARISON OF LOWER BACK PAIN AND INJURY IN COMPETITIVE AND NON-COMPETITIVE GYMNASTS

Laura Marie Parks, MS

University of Nebraska at Omaha, 2000

Advisor: Dr. Kris Berg

The purpose of this study was to compare the incidence of lower back pain and the incidence of lower back injury in non-competitive and competitive gymnasts. Secondly, the relationships of training variables with the incidence of lower back pain and lower back injury were examined. Seventy-eight female gymnasts (63 competitive and 15 non-competitive) ages 13-25 representing thirteen gymnastics clubs in the Midwest were surveyed. Each gymnast answered questions regarding years of training, weekly hours of practice, and history of low back pain and injury. Chi square analyses were done in order to compare the incidence of lower back pain and lower back injury in non-competitive gymnasts to that of competitive gymnasts. Results demonstrated no significant difference ($p \geq 0.0005$) between the incidence of lower back pain of competitive and non-competitive gymnasts as well as no significant difference ($p \geq 0.0005$) between the incidence of lower back injury of competitive and non-competitive gymnasts. Stepwise multiple regression analyses were used to predict the incidence of lower back pain and lower back injury in the total subject pool (N=78). The occurrence of previous lower back injury as diagnosed by a professional, body weight, weight training and duration of stretching explained 53.3% of the variance of the incidence of lower back pain (SEE =.28). The occurrence of lower back pain and body weight explained 38.5% of the variance of the incidence of lower back injury (SEE = .32). It was concluded that: 1) there is no difference between the incidence of lower back pain in competitive and non-competitive gymnasts; 2) there is no difference between the incidence of lower back injury in competitive and non-competitive gymnasts; 3) the occurrence of previous lower back injury as diagnosed by a professional, body weight, weight training and duration of stretching explain 53.3% of the variance in the incidence of lower back pain, while the occurrence of lower back pain and body weight explain 38.5% of the variance in the incidence of lower back injury.

Table of Contents

Chapter I

Introduction

Children are participating in organized sports at earlier ages and in increasing numbers. This trend is particularly evident in female gymnastics. Since 1980, the number of younger participants in clubs has increased dramatically (Caine, Cochrane, Caine, & Zempker, 1989). Many studies have been done in order to determine the effects of intense gymnastics training on the back.

Caine et al. (1989) report that it has consistently been shown that low back injuries are associated with women's gymnastics. Athletic children or teenagers involved in repetitious, vigorous exercises such as gymnastics develop spinal torques of great amplitude. This sort of repetitive activity concentrates considerable stress over the small area of the pars interarticularis (Bellah, Summerville, Treves, & Micheli, 1991). After analysis of the lumbar spines of 100 female gymnasts ages 6 to 24, Jackson et al., as reported by Hall (1994) reported a four times higher incidence of pars interarticularis defects than the 2.3% believed to occur in the general Caucasian female population. Fracture or disruption of the pars interarticularis is termed spondylolysis (Kennedy, 1994). Specific causal factors have not been documented. However, it is reasonable to speculate that both the occurrence of repeated impact forces and the repeated hyperextension of the lumbar spine commonly undergone by female gymnasts may contribute to the development of the type of spinal problems observed (Hall, 1986).

Wadley and Albright (1993) studied members of a women's college gymnastics team and found that 57% of the injuries sustained by the women athletes were of acute onset and were related to gymnastics. Caine et al. (1989) hypothesized that rapid periods of growth and advanced levels of training and competition are related to injury proneness in gymnasts. The average training times for these elite and competitive athletes ranged from 3 hours to 24 hours per week. In a study done by Goldstein, Berger, Windler, and Jackson (1991), it was found that 43% of elite gymnasts had spine abnormalities.

Thus far, only one study has addressed the occurrence of injuries in non-competitive or recreational gymnastics (Lowry & LeVeau, 1982). In their study, Lowry and LeVeau (1982) hypothesized that gymnastics has a high injury rate for competitors, but a low injury rate for noncompetitors. Elite athletes practice longer hours per week and practice at a higher intensity than recreational athletes. As the number of young gymnasts in clubs rises, it is important to determine the effects of recreational gymnastics on lower back injury.

Statement of Purpose

The purpose of this study was to compare the incidence of lower back pain and the incidence of lower back injury in non-competitive and competitive gymnasts. Secondly, the relationships of training variables with the incidence of lower back pain and lower back injury were examined. For the purpose of this study, the practice time of competitive gymnasts was five or more hours per week. The practice time for non-competitive gymnasts ranged from one to four hours per week.

Delimitations

The study surveyed 15 non-competitive and 63 competitive gymnasts who are or who have been enrolled in gymnastics clubs throughout Nebraska, Iowa, Kansas, Missouri, and South Dakota. Subjects were asked to complete a short questionnaire detailing practice conditions, previous back injuries, and low back pain.

Limitations

The limitations that may have affected the outcome of this study include:

1.) The short duration of the data collection period. Not all those asked to complete questionnaires were able to respond in time.

2.) Geographical constraints limiting subjects to residents of the Midwest.

3.) Recollection of training over the years

4.) The questionnaire used as a method of measurement may not include all gymnastics training variables related to lower back pain and injury.

5.) Individual perception of low back pain.

6.) Results were self-reported.

Hypotheses

The following research hypotheses were tested in this study:

1. Self-reported incidence of lower back pain in non-competitive gymnasts will be lower than that of competitive gymnasts.
2. Self-reported incidence of lower back injury rate in non-competitive gymnasts will be lower than that of competitive gymnasts.

3. Several predictors will show a correlation between gymnastics and the incidence of lower back pain and injury, specifically, weight, height, age, and competition level.

Definition of Terms

Gymnast - One trained in a sport in which individuals perform acrobatic tests to demonstrate strength, balance, and body control.

Competitive - To strive with another or others to attain a goal. Competitive training in this study consisted of five or more hours of training per week for at least three years.

Non-competitive - Performing an action merely for pleasure and not for rivalry. Non-competitive training in this study consisted of one to four hours of training per week for at least one year.

Justification

This study has potential merit because it may provide insights regarding lower back injury in competitive and non-competitive gymnastics. It will also provide information about the possible risks taken when participating in gymnastics to those young girls aspiring to be gymnasts. This study will contribute to the limited knowledge of the topic because only one study has compared non-competitive gymnastic injuries with competitive gymnastic injuries.

Chapter II

Literature Review

Literature on this information is limited as most of the current research deals with the effects of competitive gymnastics training on the back. This chapter will summarize the anatomy of the back, common back injuries related to sports, and etiology of low back injuries in gymnastics.

Anatomy of the Spine

The spinal column forms the longitudinal axis of the skeleton. It is a flexible rather than a rigid column because it is segmented. The spinal column consists of 24 vertebrae plus the sacrum and coccyx. The first seven vertebrae known as cervical vertebrae constitute the framework of the neck. The next twelve vertebrae are called the thoracic vertebrae and they constitute the upper and middle part of the back. The last five vertebrae are known as the lumbar vertebrae and support the small of the back (Thibodeau & Patton, 1997).

The lumbar vertebrae are the largest segments of the vertebral column. The body of the lumbar vertebrae is large, and its diameter is greater than those of the cervical and thoracic vertebrae. The body is slightly thicker in front than behind, flattened or slightly concave above and below, concave behind, and deeply constricted in front and at the sides. The pedicles are two short, thick pieces of bone, which project backward, one on each side, from the upper part of the body of the vertebrae. The laminae are two broad, short plates of bone which complete a neural arch formed with the pedicles. The spinous processes are thick and broad, and somewhat horizontal in direction. The transverse processes are long, slender, directed transversely outward in the upper three lumbar vertebrae. The superior articular processes are concave, and look backward and inward. The inferior articular processes are convex, and look forward and outward. The pars interarticularis is the area between the superior and inferior articular processes on each vertebrae (Gray, 1974). This area is very susceptible to sheering forces and stress fracture (Wilhite, 1997).

To increase the carrying strength of the vertebral column and to make balance possible in the upright position, the vertebral column is curved. The normal curvature of the spine is convex through the thoracic region and concave through the cervical and lumbar regions (Thibodeau & Patton, 1997).

Sport injuries to the spine can occur at the level of supporting tissue, the level of the disk, or the level of the bone. The most common injury occurs in the soft tissue (Tall & DeVault, 1993). Soft tissue includes muscle, ligament, and fascia. Soft tissues act as "guy wires" to maintain static and dynamic alignment (Wilhite, 1997).

Another structure commonly injured in the lumbar spine is the intervertebral disk. The disk consists of an annulus fibrosis and a nucleus pulposus. The annulus fibrosis is the outer layer of fibers that functions to hold the nucleus pulposus and limit its displacement during flexion, extension, and load bearing. The nucleus pulposus is a gelatinous structure occupying the central position of the annulus fibrosis. The disks provide mobility, support and protection (Wilhite, 1997). The disk is at most risk with concurrent lateral bending and axial rotation. The annulus fibrosis may tear if loads exceed the physiologic load-sharing properties (Tall & DeVault, 1993).

Injuries to the bony structures are dependent on the mechanism of injury, the force of injury, and point of application of force at the time of the injury. The injury can range from minimal avulsion-type fractures to fracture dislocations (Tall & DeVault, 1993). As with the disks, the bony structures provide mobility, support and protection (Thibodeau & Patton, 1997).

Common Back Injuries

Spondylolysis. Spondylolysis is defined as a fracture of the pars interarticularis (Kennedy, 1994). Fracture of the pars interarticularis occurs when stress in the bone exceeds the ultimate strength of the bone or its fatigue strength. The most frequent clinical pattern is back pain that is not incapacitating, but worsens after a specific event. There is usually no history of a specific injury resulting in the onset of pain. Instead, the activity and pain history are one of vigorous, repetitive athletics and indolent pain with no clear time of onset (Weir & Smith, 1989). Spondylolysis is a common cause of low back pain in the gymnast. In a roentgenographic survey of 100 female competitive gymnasts, Jackson et al., as cited by Goldberg (1980), reported an incidence of spondylolysis of 11%.

Amongst other evaluative tests during a physical examination of low back pain, spondylolysis may be detected by a specific screening test for spondylolysis. Once low back pain is felt, a screening evaluation for spondylolysis can be accomplished with the standing one-leg extension maneuver. This technique requires the patient to stand on one leg and flex the other at the knee and hip. Holding this position, the patient hyperextends. A positive test is indicated by asymmetric or unilateral pain (Weir & Smith, 1989).

Initial physical findings include only or predominantly pain, perhaps with paraspinous muscle spasm. If symptom duration is less than one year, radiographs are usually normal, though stress sclerosis or partial cracks may be evident. Bone scans are abnormal at one or both pars interarticularis (Weir & Smith, 1989).

A bone scan is performed to identify the site of fracture or fractures and to confirm the diagnosis. A high incidence of spondylolysis occurs at the fifth lumbar vertebrae (L5) level because of the susceptibility to forces acting on the L5 vertebra. The L5 vertebrae bears more weight than any other vertebral joint (Magee, 1992). Because of the weight of the upper body above L5 and any possible external load, certain forces act on the superior part of L5. These forces include: the normal force acting on the vertebral end plate; the shear force acting on the vertebral end plate; the facet force exerted by the inferior articular process of L4 onto the superior articular process of L5; and the resulting force exerted by muscles and ligamentous structures setting on the superior part of the vertebral arch (Letts, Smallman, Afanasiev, and Gouw, 1986).

Treatment for an acute lesion includes limiting offending activities for 6-8 weeks. For semi-acute lesions, bed rest is prescribed until there are no longer any symptoms, then immobilization with bracing combined with a rehabilitation exercise program is suggested. Surgery and a rehabilitation program are indicated for treatment of chronic lesions (Wilhite, 1997).

Spondylolisthesis. Spondylolisthesis is a progression of spondylolysis caused by excessive loading. Spondylolisthesis is the forward slippage of a vertebrae onto the one below it. The displacement most commonly occurs at the L5 on S1 (Wilhite, 1997). The basic lesion in spondylolisthesis is a fatigue fracture of the pars interarticularis (Goldberg, 1980).

There are four degrees of slippage with spondylolisthesis. Slippage is measured by dividing the distance the superior vertebral body has displaced forward onto the inferior one by the antero-posterior dimension of the inferior vertebral body. The degrees are classified as first degree (0-25%), second degree (25-50%), third degree (50-75%), and fourth degree (75-100%) (Wilhite, 1997). Spondylolisthesis in athletes usually represents the type in which the lesion responsible for the slippage is in the pars interarticularis either from spondylolytic defects or from an intact but elongated pars that allows forward slippage (Wilhite, 1997). A physical exam might show characteristics including flat buttocks, tight hamstrings, alteration in gait and palpable depression deformity at the level of defect (Wilhite, 1997).

Patients with spondylolisthesis will not heal the defect. Therefore, it is appropriate to treat those patients with restriction of activities until asymptomatic. This restriction is followed by back and abdominal exercises. A lumbar brace is used as symptoms dictate (Goldberg, 1980).

Herniated Disk Disease. Herniated disk disease is defined as the condition of the vertebral disk whereby the annulus fibrosis becomes disrupted, allowing the nucleus pulposus to come out (Thibodeau & Patton, 1997). The most common sites are at the L5-S1 level and the L4-5 level. Herniated disk disease has been shown to occur as a result of frequent repetitive heavy lifting and twisting (Wilhite, 1997).

There are five stages of herniated disk disease. The first stage is a normal disk. Stage two includes a slight movement of the nuclear gel. At this stage, the patient would be pain free. Stage three includes a mild to moderate protrusion of the nucleus pulposus or annulus fibrosis. The patient may have back and leg pain at this stage. At the fourth stage, a protrusion that is bulging and impinging against the nerve root occurs. The patient may have back pain, leg pain and positive neurological signs. Stage five includes disc extrusion. At this stage, neurological signs usually increase in the patient.

Herniated disk disease may present with back pain, leg pain or both. This pain is usually worsened with prolonged sitting and with Valsalva maneuvers and is usually aggravated by forward flexion. Herniated disk disease is detected in a physical exam with limited range of motion, muscle spasm, and positive sciatic tension tests. MRIs and CAT scans are performed for evaluation of possible herniated disks (Wilhite, 1997).

Treatment is usually conservative. Pain control and rehabilitation measures are taken. Bed rest is not necessary unless severe disk disease is the case. Surgery is a possibility with cases in which there is intractable pain (Wilhite, 1997).

Degenerative Disk Disease. Degenerative disk disease is a chronic and commonly progressive degeneration of the facet joints and/or the intervertebral disk (Saunders & Saunders, 1993). Degenerative disk disease is more common in the cervical spine than in the lumbar spine. Degenerative disk disease is a natural process of aging and rarely develops as the result of hypomobility (Saunders & Saunders, 1993). Joint hypermobility, however, contributes to early development of disk degeneration because of the increased wear and tear to the disks. This is important to gymnasts because gymnasts encounter hypermobility often.

The four characteristics of degenerative disk disease are: 1) Dehydration of the nucleus pulpousis; 2) Narrowing of the intervertebral space; 3) Weakening and degeneration of the annular rings; and 4) Approximation of the facet joints leading to back pain and radicular symptoms. Treatment includes back supports, muscle strengthening, postural training, modality therapy, and/or medications in mild to moderate cases. In severe cases, treatment includes bracing or support (Saunders & Saunders, 1993).

Osteoporosis. Osteoporosis is defined as a bone disorder characterized by loss of minerals and collagen from bone matrix, reducing the volume and strength of skeletal bone (Thibodeau & Patton, 1997). Osteoporosis is very common in gymnasts because they tend to have poor nutritional habits.

Etiology of Low Back Injuries in Gymnasts

Back pain in the gymnast may be due to a variety of causes ranging from a hyperlordotic back through vertebral body fractures and disorders of the intervertebral disks. Specific causal factors have not been documented; however, it is reasonable to speculate that the occurrence of repeated impact forces and the repeated hyperextension of the lumbar spine commonly undergone by female gymnasts may contribute to the development of the type of spinal problems observed (Hall, 1986). Back problems appear to result not only from single episodes of macrotrauma, but also from the repeated microtrauma in gymnastic maneuvers such as vaults, twists and hyperextension.

Repetitive microtrauma to the hyperlordotic spine secondary to repetitive hyperextension activities has been implicated in the etiology of spondylolysis (Tall & DeVault, 1993). It has been suggested by Hall (1986) that because the vertebral arches may not yet be completely ossified at the very young age that many children start gymnastics, the likelihood of spinal injury might be increased.

Athletes actively involved in sports often apply repeated flexion/extension motion at the L5-S1 level, resulting in continuous loading of the pars interarticularis. It is quite conceivable that with numerous flexion/extension movements, such as in the training of a gymnast, this area of the vertebra is indeed exposed to the dangers of fatigue fracturing (Letts et al., 1986).

A study done by Hall (1986) included four members of a university women's gymnastics team. The subjects performed all five skills which involve lumbar hyperextension: the front handspring, the back handspring, the handspring vault, the front walkover, and the back walkover. Vertical and lateral impact forces during the executions of skills were obtained from a force plate interfaced to a visicorder. Sagittal view 16-mm films were taken at 100 fps to enable evaluation of the curvature of the lumbar spine throughout the skill performances. The measurements needed for calculation of curvature were taken from film and slide projections of approximately one-third life size with quantitative digital analyzer. The reliability of this technique was calculated as $r = 0.97$ from a Pearson product moment correlation of test-retest.

Hall (1986) found that the lumbar spine was in hyperextension at the time that landing impact was sustained during the front walkover, the front handspring, and the vault. The degree of lumbar hyperextension at impact and the magnitude of the vertical impact forces were inversely related. Slight flexion occurred during the landing impacts of the back walkover and the back handspring. Maximum lumbar hyperextension during performance of these two skills occurred either at or just prior to hand impact or blocking for which impact forces were not monitored. From this data, it is apparent that hyperextension serves to shift the relative distribution of stress posteriorly and to increase the component of shear force acting on the lumbar spine when an impact force is sustained during landing on either the feet or hands.

In a study conducted by Letts et al. (1986) it was shown that stress fractures do indeed occur under situations of physiological loading. Fourteen athletes with defects in the pars interarticularis served as subjects. The most common sport engaged in was field hockey or gymnastics. The bone scans showed a reliable diagnosis of a spondylolytic stress reaction. The following sequence of events was postulated:

a. Abnormal stress such as vigorous training or competition involving multiple flexion and extension of the lumbar spine results in microfractures with attempts by the body at repair.

b. Overt fracturing occurs first on one side, resulting in overload on the other, so that microfracture and spondylolysis develop.

c. With bilateral spondylolysis, the disk now bears an unopposed shear load, and the stage is set for spondylolisthesis if excessive loading continues (Letts et al., 1986).

Another possible cause of back injuries as a result of gymnastics was hypothesized by McNaught-Davis et al., (1990). They found that gymnasts identified as having undertaken highly intensive training (i.e., performing one skill repetitiously over a given time period) were found to have a greater risk of injury. Time spent involved in training was also associated with a higher incidence of injury. The researchers also found the point during the training session at which the gymnasts performed conditioning exercises to be a factor. Gymnasts who conditioned at the beginning of the training were more exhausted by the latter part of the training session. They believed that fatigue might be associated with injury.

Steele and White (1986) found in a study of 40 competitive gymnasts (ages 10-21 yr) that 9 variables differed significantly between groups divided according to high and low lower back injury rate. Injury rate was found to be significantly associated with weight ($p < 0.001$), height ($p < 0.001$) age ($p < 0.001$), mesomorphy ($p < 0.01$), Quetlet Index ($p < 0.01$), shoulder flexion ($p < 0.05$), lumbar extension ($p < 0.05$), standing lumbar curvature ($p \leq 0.05$) and total peripheral flexibility score ($p \leq 0.05$).

Overuse is believed to be another cause of back-related injuries in gymnastics. An overuse injury can occur when tissues are not allowed sufficient time to recover after strenuous efforts. The incidence of overuse injuries tends to increase with decreased rest and increased intensity, as seen in competitive gymnasts. Weiker (1985) found that 50% of the injuries in men's gymnastics are overuse injuries. Micheli (1985) found the risk of an overuse injury often to be related with the period of rapid growth. The growth plate is very sensitive to overuse injuries during the growth spurt. Therefore, it was speculated by Micheli that overuse, especially in younger athletes, predisposes to injury of the back.

Lowry and LeVeau (1982) conducted a study in order to determine the number of injuries that occur to both competitive and noncompetitive gymnasts. The study included 4,215 participants (370 female competitors, 21 male competitors, 3,042 female noncompetitors, 377 male noncompetitors). Questionnaires were sent to 40 gymnastics clubs in North Carolina, South Carolina, Virginia, and Maryland. The questionnaires included club size, level of competition, student/instructor ratios, types of injuries, number of injuries, event in which most injuries occurred, safety equipment available, and conditioning program. It was found that noncompetitors had a much lower injury rate than competitors (female competitors = 0.70, male competitors = 0.76, female noncompetitors = 0.042, male noncompetitors = 0.0027).

Summary

From this literature review it is obvious that because of the anatomy, the back is prone to injury as a result of athletics. Results from these studies vary from one another because of discrepancies in factors such as definition of injury and sample size. It is also obvious that there are numerous injuries of the back related to sports as well as a variety of reasons why these injuries occur. Literature on these effects as a result of minimal training on the back is very limited. Therefore, it is necessary to conduct further research involving a greater number of subjects who are involved in minimal amounts of non-competitive training. This research will provide more knowledge regarding the incidence rate and correlates of injury, and may lead to the development of guidelines for injury prevention to the lower back.

Chapter III

Methods

Subjects

Subjects consisted of volunteer female gymnasts who are or were actively involved in gymnastics clubs representing a non-competitive and competitive level in the states of Nebraska, Iowa, South Dakota, Missouri, and Kansas. Sixty-three competitive and fifteen non-competitive gymnasts were sampled. Gymnastics clubs were selected using the website for USA Gymnastics Clubs. Potential subjects were excluded from the study if they have experienced any acute lower back traumatic injury outside the sport of gymnastics. The ages of the gymnasts ranged from 13 to 25 years. The practice time of each subject in the non-competitive group ranged from one to four hours per week for a minimum of 1 year. The practice time of each subject in the competitive group was five or more hours per week for a minimum of 3 years. After approval from the Institutional Review Board, subjects were contacted.

Experimental Design

This study was a non-experimental/retrospective survey. A cover letter addressed to the coach (Appendix A) accompanied the questionnaire given to the subjects and explained the purpose of the study and asked for the coach's help in distributing the questionnaires. A cover letter addressed to the parent/athlete (Appendix B) accompanied the questionnaire and explained the purpose of the study. Questionnaires were distributed to both competitive and non-competitive subjects.

The section of the questionnaire detailing the training of the gymnasts was based on a survey developed by Wadley and Albright (1993). The section of the questionnaire detailing the incidence and rating of low back pain was based on a survey developed by Congeni, McCulloch, and Swanson (1997) and a rating scale developed by Brodie, Burnett, Walker, and Lydes-Reid, (1990) as seen in Magee, (1992). The section of the questionnaire detailing the incidence and rating of low back injury was based on a survey developed by Congeni et al. (1997). The survey was examined by committee members for content validity. The survey was further validated by having several gymnastics coaches in the area critique the survey for readability and inclusion of additional information. Minor modifications to the survey were made based on the response of the coaches. Each gymnast was asked to answer questions regarding years of training, weekly hours of practice and history of low back pain and low back injury (Appendix C).

Data Collection

Cover letters and questionnaires were distributed to subjects during the spring of 2000. A follow-up letter and questionnaire was sent to those subjects who had not replied within 3 weeks (Appendix D). After completing the survey, subjects were asked to return the questionnaire using a self-addressed stamped envelope.

Data Analysis

Descriptive data are presented as a mean $\pm$ the standard deviation and range for age, body weight, height, years of training and weekly hours of practice. These data were compared in non-competitive and competitive gymnasts using independent t tests. Chi square analyses were done in order to compare the incidence of low back pain and the incidence of low back injury in non-competitive gymnasts to that of the competitive gymnasts. A multiple regression analysis was done to predict the incidence of low back pain and injury and to determine the variance in the incidence of low back pain and injury attributed to the independent variables. The independent variables included: age, height, body weight, years of training, average hours of training per week, abdominal fitness, weight training, duration of stretching, occurrence of lower back pain, and the occurrence of lower back injury as diagnosed by a professional. Level of significance was altered based on the number of comparisons made using the Bonferroni method. Ninety-six comparisons were made and therefore, an alpha level of 0.0005 (.05/96 = 0.0005) was used to denote statistical significance.

Chapter IV

Results

Seventy-eight female gymnasts representing 13 gymnastics clubs in the Midwest completed and returned the questionnaires used in data analysis (63 competitive and 15 non-competitive; mean age 15.5 $\pm$ 2.71 years old). This represented 5% of the questionnaires mailed. Subjects' descriptive characteristics can be found in Table I. No significant differences between competitive and non-competitive gymnasts were found for any of these variables.

Table I. Subject Characteristics

	Competitive (n=63)		Non-Competitive (n=15)		Total (N=78)	
	Mean	SD	Mean	SD	Mean	SD
Variable						
Age, yr	15.3	2.57	16.5	3.09	15.5	2.71
Height, cm	157.1	8.53	162.1	10.25	158.1	9.03
Weight, kg	49.3	7.31	52.8	6.59	49.8	7.28
Yr Training	8.3	2.43	6.5	3.14	7.9	2.67
Hr Training/Week	10.4	4.25	2.5	1.19	8.9	4.96

The first two hypotheses examined were not supported because there were no significant differences in the self-reported incidence of lower back injury rate and the self-reported incidence of lower back pain between competitive and non-competitive gymnasts. Several variables: the occurrence of previous lower back injury as diagnosed by a professional, body weight, weight training, duration of stretching and the occurrence of lower back pain were shown to have a significant correlation between gymnastics and the incidence of lower back pain or injury. Therefore, the third hypothesis was accepted for body weight, but was not accepted for height, age or competition level.

Subjects' training histories can be found in Table II. All subjects consistently participated on the floor exercise. Almost all competitive subjects (96.8%) consistently participated on the vault, uneven bars and balance beam while most non-competitive subjects (73.3%) consistently participated on those same apparatus (Table II). Type of landing surfaces contacted were similar among the two groups. Mats were the landing surface contacted by the majority of the gymnasts followed by spring floor (Table II). A greater number of competitive gymnasts practiced abdominal fitness ($X^2 = 4.323$, $p = 0.038$) and weight training ($X^2 = 4.325$, $p = 0.038$) than the non-competitive gymnasts (not significant at $p \leq 0.0005$). All subjects stretched as part of their training (Table II).

Table II. Training History of Subjects (Percent).
No significant differences were found.

Question	Competitive (n=63)	Non-Competitive (n=15)	Total (N=78)
Apparatus consistently participated on			
Floor	100.0	100.0	100.0
Vault	96.8	73.3	92.3
Uneven Bars	96.8	73.3	92.3
Balance Beam	96.8	73.3	92.3
Type of landing surface contacted			
Just Floor	14.3	13.3	14.1
Mats	98.4	100.0	98.7
Spring Floor	95.2	93.3	94.8
Foam Pit	23.8	13.3	21.8
Resi Pit	22.2	0.0	17.9
Is/Was abdominal fitness practiced?			
Yes	93.7	73.3	89.7
No	4.8	20.0	7.7

Table II. (Continued)

Question	Competitive (n=63)	Non-Competitive (n=15)	Total (N=78)
Did you/Do you train with weights?			
Yes	84.1	60.0	79.5
No	15.9	40.0	20.5
Is/Was stretching part of training?			
Yes	100.0	100.0	100.0
No	0.0	0.0	0.0
Length of stretching routine?			
< 5 minutes	7.9	13.3	9.0
> 5 minutes	92.1	86.7	91.0

The percentage of lower back pain in the female gymnasts can be found in Table III. The percentages of competitive and non-competitive gymnasts who experienced lower back pain were 17.5% and 38.5%, respectively. Four of the eleven competitive gymnasts experienced four or more episodes of back pain lasting longer than 7 days, while only one of the five non-competitive gymnasts experienced four or more episodes of back pain lasting longer than 7 days ($X^2 = 5.627$, $p = 0.131$). The number of times that gymnastics was discontinued for longer than 7 days varied between the two groups but no significant differences were found ($X^2 = 4.829$, $p = 0.185$). The competitive group had small percentages in the 0, 1, and 2-4 categories, while the majority of the non-competitive gymnasts were in the 0 category with only one subject in the >4 category (Table III). Lower back pain affected subjects in both groups in doing one or more activities. The activities that bothered each group varied slightly (Table III). However, no significant differences were found. When asked to rate lower back pain, the majority of competitive gymnasts (n = 6 of 11) experienced moderate pain while the majority of non-competitive gymnasts (n = 4 of 5) experienced little pain ($X^2 = 8.287$, $p = 0.040$). However, the difference was not significant at $p \leq 0.0005$.

Table III. Description of Lower Back Pain in Female Gymnasts (Percent). No significant differences were found.

Question	Competitive (n=63)	Non-Competitive (n=15)	Total (N=78)
Currently suffer lower back pain			
Yes	17.5	38.5	20.5
No	82.5	61.5	79.5
No. episodes of back pain lasting longer than 7 days			
0	3.2	0.0	2.6
1	0.0	13.3	2.6
2-4	7.9	13.3	9.0
> 4	6.3	6.7	6.4
No. of times gymnastics discontinued for longer than 7 days			
0	9.5	26.7	12.8
1	4.8	0.0	3.8
2-4	3.2	0.0	2.6
> 4	0.0	6.7	1.3

Table III. (Continued)

Question	Competitive (n=63)	Non-Competitive (n=15)	Total (N=78)
Pain still affects in which ways			
Off & on	11.1	20.0	12.8
All the time	3.2	0.0	2.6
Related to weather	4.8	6.7	5.1
Sitting	9.5	13.3	10.3
Standing	9.5	6.7	9.0
W/ routine ADLs	6.3	6.7	6.4
Lifting	9.5	20.0	11.5
Carrying	7.9	20.0	10.3
W/ ath. or rec. activities	9.5	20.0	11.5
Other	0.0	0.0	0.0
Rate pain at this moment			
No pain at all	4.8	0.0	3.8
Little pain	1.6	26.7	6.4
Moderate pain	9.5	6.7	9.0
Quite bad pain	0.0	0.0	0.0
Very bad pain	1.6	0.0	1.3
Pain is almost unbearable	0.0	0.0	1.3

Table IV describes the percentage of lower back injury in the subjects. The two groups were very similar in the percentage that sought medical attention because of a lower back injury (20.6% = competitive, 20.0% = non-competitive). The majority of those subjects with lower back injury in the competitive group (n = 7 of 13) and all of the subjects in the non-competitive group (n = 3) saw a physician. A physical exam was the method used to diagnose in the majority of competitive gymnasts (n = 11 of 13) and in all non-competitive gymnasts (n = 3 of 3). The lower back injury kept the majority of the competitive gymnasts (n = 9 of 13) from participating for 1 week while the non-competitive gymnasts were split between 1 week (n = 1 of 3) without participation and 2-

4 weeks (n = 1 of 3) without participation (X^2 = 2.885, p = 0.410). The injury occurred suddenly as a result of a specific activity in the majority of the competitive (n = 7 of 13) and non-competitive (n = 2 of 3) gymnasts (X^2 = 0.163, p = 0.687). The competitive gymnasts were divided between the floor (n = 2 of 7) and the balance beam (n = 2 of 7) as the event being performed when the injury occurred. All of the non-competitive gymnasts (n = 2 of 2) identified the balance beam as the event being performed when the injury occurred (X^2 = 1.200, p = 0.549).

Arching aggravated the lower back injury the most (n = 5 of 6) in the competitive gymnasts (6.3%) while the non-competitive group (n = 1 of 1) was split between mounting (n = 1 of 1) and non-specific activities (n = 1 of 1). The majority of the competitive gymnasts with lower back injury (n = 11 of 13) are still capable of competitive athletics while the non-competitive gymnasts with lower back injury are divided equally between competitive athletics (n = 1 of 3), recreational athletics (n = 1 of 3), and moderate activities (n = 1 of 3) (X^2 = 5.607, p = 0.061). The majority of the competitive gymnasts with lower back injury (n = 7 of 13) and all the non-competitive gymnasts with lower back injury (n = 3 of 3) rated the status of their lower back injury at the present time to be an occasional discomfort (X^2 = 2.215, p = 0.529).

Table IV. Description of Lower Back Injury in Female Gymnasts (Percent).
No significant differences were found

Question	Competitive (n=63)	Non-Competitive (n=15)	Total (N=78)
Have you sought medical attention?			
Yes	20.6	20.0	20.5
No	79.4	80.0	79.5
Which professionals were you seen by?			
Physician	11.1	20.0	12.8
Chiropractor	9.5	6.7	9.0
Athletic Trainer	7.9	0.0	6.4
Physical Therapist	4.8	6.7	5.1
Other	0.0	0.0	0.0
Which was used to diagnose?			
Physical Exam	17.4	6.7	15.4
X-ray	9.5	0.0	7.7
Bone Scan	1.9	0.0	1.3
CT scan	4.8	0.0	3.8
MRI	3.2	0.0	2.6
How long did injury keep you from participating?			
1 week	14.3	6.7	12.8
1-2 weeks	3.2	0.0	2.6
2-4 weeks	1.9	6.7	2.6
4-6 weeks	1.9	0.0	1.3
> 6 weeks	0.0	0.0	0.0
How did injury occur?			
Suddenly, as a result of a specific activity	11.1	13.3	11.5
Developed over a prolonged period	9.5	6.7	9.0
If suddenly (injured), which apparatus were you on?			
Floor	3.2	0.0	2.6
Balance Beam	3.2	6.7	3.8
Uneven Bars	1.6	0.0	1.3
Vault	0.0	0.0	0.0

Table IV. (Continued)

Question	Competitive (n=63)	Non-Competitive (n=15)	Total (N=78)
If (injured) over time, which activities aggravate it?			
Mount	1.6	6.7	2.6
Dismount	4.8	0.0	3.8
Stunt	1.6	0.0	1.3
Falling	4.8	0.0	3.8
Twist	3.2	0.0	2.6
Arching	6.3	0.0	5.1
Piking	4.8	0.0	3.8
Non-specific	0.0	6.7	1.3
Pain still affects in which ways?			
Off & on	14.3	13.3	14.1
All the time	3.2	0.0	2.6
Related to weather	4.8	6.7	5.1
Sitting	6.3	6.7	6.4
Standing	7.9	13.3	9.0
W/ routine ADLs	4.8	6.7	5.1
Lifting	6.3	13.3	7.7
Carrying	6.3	13.3	7.7
W/ ath. or rec. activities	4.8	13.3	6.4
Other	0.0	0.0	0.0
Highest level of physical activity still capable of?			
Competitive athletics/activity	17.5	6.7	15.4
Recreational athletics/activity	3.2	6.7	3.8
Moderate activity	1.6	6.7	2.6
Limited activity	0.0	0.0	0.0
Limited in activities of daily living	0.0	0.0	0.0
Rate status of injury today			
Full recovery, no problems	6.3	0.0	5.1
Occasional discomfort	11.1	20.0	12.8
Chronic symptoms	1.9	0.0	1.3
Permanent condition	1.9	0.0	1.3

The results of the multiple regression analyses can be found in Tables V and VI. No significant differences between the groups were found on any of the variables and therefore the regression equations were developed pooling all subjects together. The occurrence of lower back pain was determined by asking the subjects whether or not they currently suffer low back pain that has been ongoing since they became a gymnast. The answers were dummy coded so that 1 = Yes and 2 = No. Four variables entered into the multiple regression equation for the incidence of lower back pain in all of the female gymnasts (N=78). These four variables were the occurrence of previous lower back injury as diagnosed by a professional, body weight, weight training, and duration of stretching. These four variables explained 53.3% of the variance in lower back pain with a standard error of estimate (SEE) of .28.

The occurrence of lower back injury was determined by asking the subjects whether or not they have sought medical attention for any lower back injury at any time or for any reason since the beginning of gymnastics participation. The answers were dummy coded so that 1 = Yes and 2 = No. Two variables entered into the multiple regression equation for the incidence of lower back injury using all of the female gymnasts (N=78). These two variables were the occurrence of lower back pain and body weight. These two variables explained 38.5% of the variance in lower back injury with a SEE of .32.

Table V. Stepwise Regression Predicting Lower Back Pain in All Gymnasts (N=78)

Step	Variable	R	R^2 x 100	B	SEE
1	Medical Attention Sought for Previous Lower Back Injury	.583	34.0	.583	.33
2	Body Weight	.665	44.2	-.319	.30
3	Weight Training	.710	50.4	-.268	.29
4	Duration of Stretching	.730	53.3	.175	.28

$$Y' = 1.438 + .472 (X_1) - .013 (X_2) - .277 (X_3) + .257 (X_4)$$

Table VI. Stepwise Regression Predicting Lower Back Injury in All Gymnasts (N=78)

Step	Variable	R	R^2 x 100	B	SEE
1	Occurrence of Lower Back Pain	0.583	34.0	.583	0.33
2	Body Weight	0.620	38.5	.222	0.32

$$Y' = .014 + .651 (X_1) + .012 (X_2)$$

Chapter V

Discussion

Summary of Findings

The first hypothesis was that self-reported incidence of lower back pain in non-competitive gymnasts will be lower than that of competitive gymnasts. Results demonstrated no significant difference ($p \geq 0.0005$) between lower back pain of competitive and non-competitive gymnasts.

The second hypothesis was that self-reported incidence of lower back injury rate in non-competitive gymnasts will be lower than that of competitive gymnasts. No significant difference ($p \geq 0.0005$) between lower back injury rate of competitive and non-competitive gymnasts was demonstrated.

The third hypothesis was that several predictors will show a correlation between gymnastics and the incidence of lower back pain and lower back injury, specifically, body weight, height, age, and competition level. Body weight was found by the present study to have a negative correlation with the incidence of lower back pain and a positive correlation with the incidence of lower back injury. Therefore, the third hypothesis was supported for the correlation of body weight and the incidence of lower back pain and injury. This correlation means that as body weight increased, there was an increase in the incidence of lower back pain. However, the incidence of lower back injury decreased as body weight increased. Height, age and competition level were not significantly correlated with either lower back pain or injury. Because no significant differences between the groups were found on any of the predictor variables the regression equations were developed pooling all subjects together. The results of the stepwise multiple regression analyses showed that four variables entered into the multiple regression equation for the incidence of lower back pain in all of the female gymnasts (N=78). These four variables explained 53.3% of the variance in the incidence of lower back pain with a standard error of estimate (SEE) of .28. This SEE means that the incidence of lower back pain can be predicted within .28 arbitrary units where 1 equals having lower back pain and 2 equals not having lower back pain. The SEE of .28 can also be interpreted to mean that 68% of the time a person's lower back pain was estimated using the regression equation the score for the dependent variable will be within .28 arbitrary units.

The results of the stepwise multiple regression analysis for lower back injury showed that two variables entered into the multiple regression equation using all of the female gymnasts (N=78). These two variables explained 38.5% of the variance in the incidence of lower back injury with a SEE of .32. This SEE means that the incidence of lower back injury can be predicted within .32 arbitrary units where 1 equals having lower back injury and 2 equals not having lower back injury. The SEE of .32 can also be interpreted to mean that 68% of the time a person's lower back injury was estimated using the regression equation the score for the dependent variable will be within .32 arbitrary units.

Comparison with Literature

No studies have been done that compare the incidence of lower back pain in competitive and non-competitive gymnasts. Thus far, only one study has addressed the occurrence of injuries in non-competitive or recreational gymnastics (Lowry & LeVeau, 1982). In their study, Lowry and LeVeau (1982) hypothesized that gymnastics has a high injury rate for competitors, but a low injury rate for non-competitors. They examined the relationship of selected variables with injury rate. The variables included club size, level of competition, student/instructor ratios, types of injuries, number of injuries, event in which most injuries occurred, safety equipment available, and conditioning program. The findings of the present study do not agree with those of Lowry and LeVeau. Lowry and LeVeau found that non-competitors had a much lower injury rate than competitors (female competitors = 0.70, male competitors = 0.76, female non-competitors = 0.042, male non-competitors = 0.0027). Statistical tests and significance levels of their study were not reported.

The majority of the competitive and non-competitive gymnasts in the present study experienced lower back injury suddenly, as a result of a specific activity (competitive: n = 7 of 13 and non-competitive: 2 of 3). This finding agrees with that of Wadley and Albright (1993) who found that 57% of the injuries sustained by the women athletes were of acute onset and related to gymnastics. However, this result disagrees with the conclusion of Caine et al. (1989) and Hall (1986) that most back injuries are characterized by gradual onset. In the present study the event in which the injury occurred varied slightly between the two groups. Two of the seven injuries in the competitive group occurred on the floor (n = 2 of 7) and the balance beam (n = 2 of 7), while all the non-competitive gymnasts injuries (n = 2 of 2) were on the balance beam. The difference between the groups was not significant ($p \geq 0.0005$). The inability to detect a significant difference is probably due to the small number of cases compared. Although this finding was not significant it is important to note that all of the non-competitive gymnasts and the majority of the competitive gymnasts were on the balance beam at the time their lower back injury occurred. This finding supports the findings of Weiker (1985) who found that more injuries occurred on the balance beam than during other gymnastics events. One can speculate that because of the height of the beam, the spine absorbs more force during the impact of landing than in other events. This force, along with the extreme hyperextension the gymnast experiences immediately after landing, may contribute to excessive stress to the lower back.

A study done by Hall (1986) examined the vertical and lateral impact forces during the executions of five skills with lumbar hyperextension: the front handspring, the back handspring, the handspring vault, the front walkover, and the back walkover. It was found that the lumbar spine was in hyperextension at the time that landing impact was sustained during the front walkover, the front handspring, and the vault. The degree of lumbar hyperextension at impact and the magnitude of the vertical impact forces were inversely related. Slight flexion occurred during the landing impacts of the back walkover and the back handspring. Maximum lumbar hyperextension during performance of these two skills occurred either at or just prior to hand impact or blocking for which impact forces were not monitored. From these findings, it is apparent that hyperextension serves to shift the relative distribution of stress posteriorly and to increase the component of shear force acting on the lumbar spine when an impact force is sustained during landing on either the feet or hands. It can be speculated that the spine will be affected in the same way when landing from the balance beam but to a greater extent because of the height of the beam.

Letts et al. (1986) postulated the sequence of events leading to a defect in the pars interarticularis of gymnasts and field hockey players to be as follows:

a. Abnormal stress such as vigorous training or competition involving multiple flexion and extension of the lumbar spine results in microfractures with attempts by the body at repair.

b. Overt fracturing occurs first on one side, resulting in overload on the other, so that microfracture and spondylolysis develop.

c. With bilateral spondylolysis, the disk now bears an unopposed shear load, and the stage is set for spondylolisthesis if excessive loading continues

From the results of the study by Letts et al. (1986) it was shown that stress fractures do indeed occur under situations of physiological loading. The present study only assessed the occurrence of acute injuries on the balance beam. However, it is possible that the balance beam can lead to chronic overload of the spine. It can be speculated that the spine undergoes the physiological loading described by Letts et al. (1986) when a gymnast repeatedly lands from the balance beam.

The relationship between body weight and the incidence of lower back injury rate found by the multiple regression analysis was the only finding in the present study that agreed with the findings of Steele and White (1986). In addition to the variables that were not considered in the present study, Steele and White (1986) also found height and age to correlate with lower back injury rate. As both height and age increased, lower back injury rate increased. These variables did not enter the regression equation in the present study.

Interpretation of Findings

The regression equations for lower back pain and lower back injury will be interpreted here based on the sign of the correlation of each variable with the dependent variable. This facilitates understanding the role of these variables in the context of lower back pain and injury. The dependent variable, the incidence of lower back pain, was determined by asking the subjects if they currently suffer low back pain that has been ongoing since becoming a gymnast. Subjects responded either yes or no. The dependent variable, the incidence of lower back injury, was determined by asking the subjects if they sought medical attention for any previous lower back injury at any time or for any reason since the beginning of gymnastics participation. Subjects responded either yes or no. The data of the present study were dummy coded so that 1 = Yes and 2 = No. The dummy code values are important to note in interpreting the relationships found.

In the multiple regression equation for the incidence of lower back pain two variables were found to have a positive correlation with lower back pain and two variables were found to have a negative correlation. The results of the present study indicate that seeking medical attention for a previous lower back injury is positively correlated to lower back pain. That is, if a gymnast has been seen by a professional and has been diagnosed with a lower back injury, he/she is more likely to experience lower back pain than a gymnast without a lower back injury. Simply said, the occurrence of a lower back injury increases the incidence of lower back pain in a gymnast, which encourages seeking medical attention.

The second variable in the regression equation for lower back pain, body weight, was negatively correlated to lower back pain. Hence, heavier gymnasts are more likely to experience lower back pain. It is logical to assume that the greater the body weight, the greater the amount of stress placed on the vertebral column. This increase in stress may then lead to lower back pain.

The third variable that entered the regression equation for the incidence of lower back pain, weight training, is also negatively correlated to lower back pain. Thus, those gymnasts who train with weights as part of gymnastics conditioning are less likely to experience lower back pain. This finding supports the recommendations that muscular conditioning is important in prevention of lower back pain. Increased muscle strength provides protection against injury because it helps to maintain good posture and appropriate body mechanics when performing activities such as gymnastics skills (Fahey, Insel & Roth, 1994). Fahey et al.(1994) suggest that strong muscles in the abdomen, hips, low back, and legs support the back and help in the prevention of lower back pain. Goldberg (1980) advises that a careful combination of stretching and strengthening be included in gymnastics training.

The fourth variable in the regression equation for the incidence of lower back pain, the duration of stretching as part of training, is positively related to lower back pain.

This means that gymnasts who stretch for longer than five minutes as part of gymnastics training are less likely to experience lower back pain. This finding supports the suggestion that stretching is important in prevention of lower back pain. Poor flexibility in the back, pelvis, and thighs can increase the curve of the lower back and cause the pelvis to tilt too far forward (Fahey, Insel, & Roth, 1994). Foster and Fulton (1991) suggest that pelvic mobility is essential in bending and lifting activities, and tightness of the hip flexor muscles may limit pelvic movement and cause excessive strain on the lumbar spine. They also suggest that tightness of the hip extensor muscles may reduce lumbar lordotic curve, making the spine less resilient to axial loading. Goldberg (1980) advises that a careful combination of stretching and strengthening be included in gymnastics training. These four variables: occurrence of a previous lower back injury as diagnosed by a professional, body weight, weight training and duration of stretching explained 53.3% of the variance in the incidence of lower back pain. The regression equation developed is: Y ` = 1.438 + .472 (the occurrence of previous lower back injury as diagnosed by a professional) - .013 (body weight) - .277 (weight training) + .257 (duration of stretching).

Regarding the incidence of lower back injury, two variables entered the regression equation. Both of the variables were shown to have a positive correlation with lower back injury. A positive relationship between those gymnasts who suffer lower back pain and the occurrence of a lower back injury was observed. This finding is somewhat self-explanatory. It appears that lower back injury leads to the occurrence of lower back pain. The second variable in the regression equation for the incidence of lower back injury, body weight, was also shown to have a positive correlation with lower back injury. As body weight increases, the number of lower back injuries decrease. This finding may in part be explained by the criterion used to define injury. Injury denoted having seen a medical professional. However, not all injured gymnasts may have gone to such a specialist and been diagnosed. Also, it is possible that greater weight was associated with greater physical maturity which may be protective of injury due to greater muscular strength and soft tissue development. These two variables, occurrence of lower back pain and weight, explained 38.5% of the variance in the incidence of lower back injury. The regression equation developed is: $Y' = .014 + .651$ (occurrence of lower back pain) + .012 (weight).

Predictor variables found in the present study to relate to incidence lower back pain and lower back injury perhaps can be used to help prevent lower back pain and lower back injury in gymnasts. Early medical diagnosis and treatment of a lower back injury seem to be preventative of further injuries and lower back pain. Weight training appears worthwhile in the prevention of lower back pain. The repetitive stresses placed on a poorly conditioned body by the nature of the sport of gymnastics might cause lower back pain. Strengthening the trunk muscles should enhance stabilizing the spine and reducing overall torque on the disks. Increased leg strength should facilitate shock absorption via the muscles instead of other joint tissues. Stretching may also be important in the prevention of lower back pain. Stretching that lasts longer than five minutes is associated with lower incidence of lower back pain. Lastly, early detection of the cause of low back pain and taking the necessary time off may facilitate preventing lower back injuries.

Limitations

Several limitations occurred in this study. One major limitation to the study is the small sample size. The small N size limits the statistical power. Also, because the number of non-competitive gymnasts was so much less than the competitive gymnasts, it is difficult to make a sound comparison between the two groups. Because the N size was small, it is not a representative sample of Midwest gymnasts. The short duration of the data collection period might have affected the sample size because not all those asked to complete the questionnaires may have responded in time. Another limitation might be that all the subjects were female gymnasts. The geographical constraints which limited subjects to residents of the Midwest may be another limitation to the study. The data may not well represent all gymnasts in the Midwest, however, subjects from a variety of gymnastic clubs in each of the five states responded. Because subjects might have a problem accurately recalling details of their training over the years, the data might not be completely accurate. The questionnaire used as a method of measurement may not have included some information that is critical in determining the relationship between gymnastics training and lower back injury. There might also be a difference in the opinion of what subjects perceived to be low back pain. Also, all results were self-reported. Obviously, further research is needed to better understand the relationship of training variables to the incidence of lower back pain and injury, and to determine if competitive and non-competitive gymnasts suffer lower back pain and injury at different rates.

Chapter VI

Summary, Recommendations and Conclusions

Summary

Most literature in the past about gymnastics has been limited to competitive gymnasts. As seen, there is evidence that competitive gymnastics may be related to lower back injury and lower back pain (Caine et al., 1989; Bellah, Summerville, Treves, & Micheli, 1991; Hall, 1994; Kennedy, 1994; Wadley & Albright, 1993). One study compared competitive and non-competitive gymnastics and found that competitive gymnastics contributed to a higher injury rate than non-competitive gymnastics (Lowry & LeVeau, 1982).

The purpose of this study was to compare the incidence of lower back pain and the incidence of lower back injury in non-competitive and competitive gymnasts. Secondly, the relationships of training variables with the incidence of lower back pain and lower back injury were examined. Seventy-eight female gymnasts (63 competitive and 15 non-competitive) ages 13-25 and representing thirteen gymnastics clubs in the Midwest were surveyed. Each gymnast answered questions regarding years of training, weekly hours of practice, and history of low back pain and low back injury. Chi square analyses were done in order to compare the incidence of low back pain and the incidence of low back injury in non-competitive to that of competitive gymnasts. Results demonstrated no significant difference ($p \geq 0.0005$) between the incidence of lower back pain of competitive and non-competitive gymnasts as well as no significant difference ($p \geq 0.0005$) between the incidence of lower back injury of competitive and non-competitive gymnasts. Stepwise multiple regression analyses were used to predict the incidence of lower back pain and the incidence of lower back injury in the total subject pool (N=78). The occurrence of previous lower back injury as diagnosed by a professional, weight, weight training and duration of stretching explained 53.3% of the variance of the incidence of lower back pain (SEE = .28). The regression equation developed is: Y ` = 1.438 + .472 (the occurrence of previous lower back injury as diagnosed by a professional) - .013 (body weight) - .277 (weight training) + .257 (duration of stretching). The occurrence of lower back pain and body weight explained 38.5% of the variance of the incidence of lower back injury (SEE = .32). The regression equation developed is: Y ` = .014 + .651 (occurrence of lower back pain) + .012 (body weight).

Recommendations

Based on the results of the present study, it is recommended that further research include a larger N size, with both male and female subjects included. One way to increase the N size might be to approach the gymnasts personally rather than mailing questionnaires to the coaches and asking them to distribute the questionnaires. More studies are needed to compare lower back pain and injury in competitive and non-competitive gymnasts. It would be advantageous to include a wider range of states than just the five in the Midwest. It might also be beneficial to use some type of rating scale that would determine the degree of physical exertion the gymnast feels he/she experiences in a normal day of training. This could be used to gauge the training level of the gymnast. Another aspect that might be advantageous would be to determine the longterm effects of competitive and non-competitive gymnastics training on the lower back. Based on the results of this study, it appears that weight training and stretching for longer than 5 minutes might benefit the gymnast. However, further research is needed to support this finding.

Conclusions

Based on the results of this study the following conclusions are warranted:

1. There was not a significant relationship between self-reported incidence of lower back pain in non-competitive and competitive gymnasts.
2. There was not a significant relationship between self-reported incidence of lower back injury rate in non-competitive and competitive gymnasts.
3. The occurrence of previous lower back injury as diagnosed by a professional, body weight, weight training, and duration of stretching are predictors of incidence of lower back pain.
4. The occurrence of lower back pain and body weight are predictors of incidence of lower back injury.

References

Bellah, R.D., Summerville, D.A., Treves, S.T., and Micheli, L.J. (1991). Low-back pain in adolescent athletes: Detection of stress injury to the pars interarticularis with SPECT. Radiology, 180, 509-512.

Brodie, D.J., Burnett, J.V., Walker, J.M., and Lydes-Reid, D. (1990). Thermometer pain rating scale. In Magee, D.J., Orthopedic Physical Assessment. Philadelphia, PA: W.B. Saunders Company.

Caine, D., Cochrane, B., Caine, C., and Zempker, E. (1989). An epidemiologic investigation of injuries affecting young competitive female gymnasts. The American Journal of Sports Medicine, 17, 811-820.

Congeni, J., McCulloch, J., and Swanson, K. (1997). Lumbar spondylolysis: A study of natural progression in athletes. The American Journal of Sports Medicine, 25, 248-253.

Goldberg, M.J. (1980). Gymnastic injuries. Orthopedic Clinics of North America, 11, 717-722.

Goldstein, J.D., Berger, P.E., Windler, G.E., and Jackson, D.W. (1991). Spine injuries in gymnasts and swimmers. The American Journal of Sports Medicine, 19, 463-468.

Gray, H. (1974). Gray's Anatomy. Philadelphia, PA: Running Press.

Fahey, T.D., Insel, P.M., and Roth, W.T. (1994). Fit & Well. Mountain View, CA: Mayfield Publishing Company.

Foster, D.N., Fulton, M.N. (1991). Back pain and the exercise prescription. Clinics in Sports Medicine, 10, 197-209.

Hall, S.J. (1986). Mechanical contribution to lumbar stress injuries in female gymnasts. Medicine and Science in Sports and Exercise, 18, 599-601.

Kennedy, K. (1994). Acute spondylolysis in an adolescent. Orthopedic Nursing, 13, 17-20.

Letts, M., Smallman, T., Afanasiev, R., and Gouw, G. (1986). Fracture of the pars interarticularis in adolescent athletes: A clinical-biomechanical analysis. Journal of Pediatric Orthopedics, 6, 40-46.

Lowry, C.B. and LeVeau, B.F. (1982). A retrospective study of gymnastics injuries to competitors and noncompetitors in private clubs. The American Journal of Sports Medicine, 10, 237-239.

Magee, D.J. (1992). Orthopedic Physical Assessment. Philadelphia, PA: W.B. Saunders Company.

Micheli, L.J. (1985) Back injuries in gymnastics. Clinics in Sports Medicine, 4, 85-93.

Saunders, H.D. and Saunders, R. (1993). Evaluation, Treatment and Prevention of Musculoskeletal Disorders. Chaska, MN: The Saunders Group.

Steele, V.A. and White, J.A. (1986). Injury prediction in female gymnasts. British Journal of Sports Medicine, 20, 31-33.

Tall, R.L. and DeVault, W. (1993). Spinal injury in sport: Epidemiologic considerations. Clinics in Sports Medicine, 12, 441-447.

Tertti, M., Paajanen, H., Kujala, U.M., Alanen, A., Salmi, T.T., and Kormano, M. (1990). Disc degeneration in young gymnasts. The American Journal of Sports Medicine, 18, 206-208.

Thibodeau, G.A. and Patton, K.T. (1997). Anatomy & Physiology. St. Louis: Mosby-Year Book Inc.

Wadley, G.H., & Albright, J.P. (1993). Women's intercollegiate gymnastics injury Patterns and "permanent" medical disability. The American Journal of Sports Medicine, 18, 599-601.

Weiker, G.G. (1985). Injuries in club gymnastics. Physician Sportsmedicine, 13, 63-66.

Weir, M.R. and Smith, D.S. (1989). Stress reaction of the pars interarticularis leading to spondylolysis. Journal of Adolescent Health Care, 10, 573-577.

Wilhite, J.M. (1997). Thoracic and lumbosacral spine. In Mellion, M.B. , Walsh, W.M., and Shelton, G.L. (Eds.), The Team Physician's Handbook. Philadelphia, PA: Hanley & Belfus.

University of
Nebraska at
Omaha

School of Health, Physical
Education and Recreation
Omaha, Nebraska 68182-0216
(402) 554-2670
FAX (402) 554-3693

Appendix A

Cover Letter to Coach

Dear Coach,

As part of my Master's Degree Thesis, I am surveying various gymnasts throughout the Midwest. The survey will be used to obtain information regarding low back pain, low back injury and training variables related to low back pain and low back injury. Information gained from this study may help gymnastics instructors and health professionals learn more about care of the lower back in young gymnasts.

One hundred copies of the survey are enclosed. Please distribute the surveys to those gymnasts you work with between the ages of 13-25 years old who have participated in gymnastics for a minimum of 1 year. The purpose of this study is to compare lower back injury and pain in non-competitive and competitive gymnasts. Please try to have equal numbers of gymnasts in each group complete the survey. Results of the survey will be sent to you this spring.

Your assistance is greatly appreciated!

Sincerely,

Laura M. Parks, Graduate Student
School of HPER, University of Nebraska at Omaha

University of
Nebraska at
Omaha

School of Health, Physical
Education and Recreation
Omaha, Nebraska 68182-0216
(402) 554-2670
FAX (402) 554-3693

Appendix B

Cover Letter to Parent/Athlete

Dear Parent/Athlete,

As part of my Master's Degree Thesis, I am surveying various gymnasts throughout the Midwest. The survey will be used to obtain information regarding low back pain, low back injury and training variables related to low back pain and low back injury. Information gained from this study may help gymnastics instructors and health professionals learn more about care of the lower back in young gymnasts.

Subjects must be between the ages of 13-25 years old and have participated in gymnastics for a minimum of 1 year.

Please fill out the questionnaire enclosed and using the self-addressed stamped envelope, return it by February 25, 2000. The questionnaire should take approximately 10 minutes to complete. Results of the survey will be sent to your coach this spring who can distribute them to you.

Your assistance is greatly appreciated!

Sincerely,

Laura M. Parks, Graduate Student
School of HPER, University of Nebraska at Omaha

Appendix C

Low Back Pain and Injury Questionnaire

1. Gender: M F 2. Age (to nearest year): ____ 3. Height: ___ft____in 4. Weight (lb): ____

Training

5. Years of Training: ______

6. Average Hours of Training/Week over these years: ________

7. Apparatus that you consistently participate/participated on? (Please check all that apply)

   Males: Pommel Horse ___ Rings ___ Parallel Bars ___ Floor ___ Vault___ Horizontal Bar ___

   Females: Uneven Bars ___ Balance Beam ___ Vault ___ Floor ___

8. What type of landing surface do/did you come into contact with? (Please check all that apply)

   Just floor ___ Mats ___ Spring Floor ___ Foam Pit ___ Resi Pit ___

9. Is/Was abdominal fitness (Example: Performing bent knee trunk curls/crunches) practiced on a regular basis? (Circle one) YES NO

10. Do you/did you train with weights as a part of your gymnastics conditioning? YES NO

11. Is/Was stretching a part of your training? YES NO

12. If YES, how long does/did your stretching routine typically last?

    <5 minutes ____
    >5 minutes ____

Low Back Pain

13. Do you currently suffer low back pain that has been ongoing since you became a gymnast? YES NO

14. If NO, proceed to question number 18

For question 15, please check all that apply for pain occurring during years of active participation in gymnastics:

15. a. Number of episodes of back pain lasting longer than 1 week

    0 ____
    1 ____
    2-4 ____
    > 4 ____

    b. Number of times gymnastics was discontinued for longer than 1 week due to low back pain

    0 ____
    1 ____
    2-4 ____
    > 4 ____

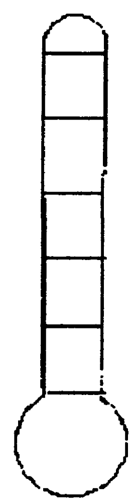
16. Does this pain now affect you in any of the following ways or doing any activities? YES NO
(check all that apply)

__ Off & on, throughout the day
__ All the time
__ Related to weather changes
__ Sitting
__ Standing
__ With routine activities of daily living (Ex: walking to car, taking out garbage, walking stairs)
__ Lifting
__ Carrying
__ With athletic or recreational activities
__ Other: ______________________

17.

Pain Rating Scale

To the right is a thermometer with various grades of pain on it from "No Pain at all" to "The pain is almost unbearable." Put an X by the words that describe your pain best AT THIS MOMENT IN TIME.



The pain is almost unbearable _____
Very bad pain _____
Quite bad pain _____
Moderate pain _____
Little pain _____
No Pain at all _____

Low Back Injury
(Please answer questions 18-27 based on the most bothersome lower back injury you have had)

18. Have you sought medical attention for any lower back injury at any time or for any reason since the beginning of your gymnastics participation? YES NO

If NO, go to question number 28

For what reason? ____

Which of the following professionals were you seen by? (Circle all that apply)

Physician Chiropractor Athletic Trainer Physical Therapist Other __________

What was the diagnosis?____
(If you don't know, leave blank)

19. Which of the following methods was used to diagnose your low back injury? (Check all that apply)

___ Physical Examination
___ X-ray
___ Bone scan
___ CT scan
___ MRI

20. How long did your injury keep you from participating?

___ 1 week
___ 1-2 weeks
___ 2-4 weeks
___ 4-6 weeks
___ > 6 weeks

21. Did your injury: (Please check one)

Suddenly occur as a result of a specific activity ___   Develop over a prolonged period ___

22. If the injury occurred as a result of a specific gymnastics activity, can you identify the apparatus you were performing on when the injury occurred?   YES   NO

23. If YES, what was the apparatus? (Please circle one)

Floor   Balance Beam   Uneven Bars   Parallel Bars   Vault   Pommel Horse   Rings   Horizontal Bar

24. If the injury occurred over a prolonged period what gymnastics activities aggravate/aggravated it?

___ Mount
___ Dismount
___ Stunt
___ Falling
___ Twist
___ Arching
___ Piking
___ Non-specific

25. Does this injury still affect you in any of the following ways or doing of any activities?   YES   NO
(check all that apply)

__ Off & on, throughout the day
__ All the time
__ Related to weather changes
__ Sitting
__ Standing
__ With routine activities of daily living (ex. walking to car, taking out garbage, walking stairs)
__ Lifting
__ Carrying
__ With athletic or recreational activities
__ Other:

26. Please indicate the highest level of physical activity that you feel you are now capable of with regard to this injury:

__ Competitive athletics/ activity
Such as: competitive gymnastics, competitive tennis/racquetball, soccer, downhill skiing
__ Recreational athletics/activity
Such as: Recreational gymnastics, tennis or racquetball, jogging, high-impact aerobics
__ Moderate activity
Such as: Bicycling, swimming, fitness walking, weight training, rowing machine
__ Limited activity
No recreational or athletic activity
Not limited in activities of daily living
__ Limited in activities of daily living

27. Overall, how would you rate the status of this injury at this time today?
(Please select one)
__ Full recovery, no problems at all
__ Occasional discomfort
__ Chronic symptoms
__ Permanent condition (do not expect it to improve)

28. Have you ever been diagnosed with an eating disorder ? YES NO

University of
Nebraska at
Omaha

School of Health, Physical
Education and Recreation
Omaha, Nebraska 68182-0216
(402) 554-2670
FAX (402) 554-3693

Appendix D

Follow-up Letter

Dear Parent/Athlete,

I am sorry to trouble you again, but would really appreciate your help. As part of my Master's Degree Thesis, I am surveying various gymnasts throughout the Midwest. The survey will be used to obtain information regarding low back pain, low back injury and the training variables related to low back pain and low back injury. Information gained from this study may help gymnastics instructors and health professionals learn more about care of the lower back in young gymnasts.

Subjects must be between the ages of 13-25 years old and have participated in gymnastics for a minimum of 1 year.

Please fill out the questionnaire enclosed and using the self-addressed stamped envelope, return it by March 17, 2000. Results of the survey will be sent to your coach this spring who can distribute them to you.

Your assistance is greatly appreciated!

Sincerely,

Laura M. Parks, Graduate Student
School of HPER, University of Nebraska at Omaha