CHEERLEADING: A COMPREHENSIVE STUDY OF BIOMECHANICS, COMMON INJURIES, PREVENTION AND REHABILITATION OF INJURIES

A Case Report

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Doctor of Physical Therapy

By

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APPROVAL SHEET

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# TABLE OF CONTENTS

ACKNOWLEDGEMENTS ........................................................................................................... 6

ABSTRACT ..................................................................................................................................... 7

INTRODUCTION ............................................................................................................................ 8

COMPETITIVE CHEERLEADING CATEGORIES ........................................................................ 9

BIOMECHANICS ........................................................................................................................... 9

- Spotter ...................................................................................................................................... 9
- Base ......................................................................................................................................... 11
- Partner ...................................................................................................................................... 13

BIOMECHANICS OF SPECIFIC STUNTS .................................................................................. 14

- The Cradle ............................................................................................................................... 15
- Single-based Shoulder Stand ................................................................................................... 16
- The Pyramid ............................................................................................................................. 18

INJURIES ...................................................................................................................................... 20

- Mechanism of Injury ................................................................................................................ 21
- Catastrophic Injuries .................................................................................................................. 22

MOST COMMON INJURIES, REHABILITATION, AND PREVENTION ..................................... 24

- Ankle Sprain and Rehabilitation ............................................................................................... 24
- Injury Prevention Program via Balance Training for Ankle Sprains ........................................ 29
- Neck Pain with Movement Coordination Impairments: Strain/Sprain of Cervical Spine 31
- Neck Sprain/Strain and Rehabilitation ....................................................................................... 34
- Cervical Spine Strengthening and Injury Prevention ................................................................. 36
- Concussion ................................................................................................................................ 39
Rehabilitation and Return to Play Protocol Post-Concussion..............................39
Prevention Strategies for Concussion...............................................................41
Low Back Strains and Sprains.......................................................................42
Lumbar Strains and Sprains and Rehabilitation..............................................44
Prevention of Low Back Injury with Core Stability Exercise........................44
SURFACES, FLOORING, AND INJURY PREVENTION.................................46
WARMING UP AND INJURY PREVENTION......................................................48
STRETCHING AND INJURY PREVENTION.....................................................50
BALANCE AND INJURY PREVENTION..........................................................52
PRE-PARTICIPATION SCREENING.................................................................52
INJURY PREVENTION VIA RESISTANCE TRAINING AND CONDITIONING.....54
   Periodization...............................................................................................55
   In-season and Off-season Training.............................................................59
   Training for Power......................................................................................61
   Other Periodization Considerations..........................................................62
READINESS TO RETURN TO COMPETITION...............................................66
SUMMARY.......................................................................................................67
REFERENCES.................................................................................................69
APPENDIX A: BIOMECHANICS OF CRADLE STUNT.......................................77
APPENDIX B: CASE PRESENTATION AND RISK MANAGEMENT OF A
PROFESSIONAL CHEERLEADER.................................................................79
   Abstract....................................................................................................79
   Background and Purpose..........................................................................80
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Abstract

Cheerleading is now a competitive sport that continues to gain popularity all over the world, not just in the United States.¹ As the sport evolves to include a higher number of participants and more complex routines, incorporating increasingly risky maneuvers, there is potential for a higher incidence of injury in athletes participating in this sport.² This Independent Study will assist in the development of knowledge in the sport of cheerleading, the biomechanics and proper technique for completing various stunts; common mechanisms of injury and types of injuries that cheerleaders incur; prescribing or implementing resistance training (RT) programs which would increase the cheerleader’s preparedness (addressing power, strength, flexibility, and endurance) and reduce the athlete’s risk for injury. In addition, appropriate therapeutic exercises for rehabilitation of injured athletes in order to “return to play” as early and as safely as possible are discussed along with how various surfaces affect the probability of incurring a catastrophic injury and to be able to suggest appropriate training/competition surfaces for various types of routines. Because injury prevention begins with an athlete being in adequate physical condition for sport performance, this study will include parameters for a periodized resistance training program designed for a high school competitive cheerleader. Incorporated within the paper will be a case study describing the mechanism of injury of a professional cheerleader as well as risk management techniques to address injury prevention. By conducting a thorough investigation of all of the above topics related to competitive cheerleading and being proactive on educating the cheerleading community, it is hoped that safer conditions for athletes and a reduction of the incidence of injury in this athletic population can be made.
Introduction

From pom-poms, chants, and fight songs led by male dominated squads to the cradles, stunts, and back handsprings of primarily female teams, cheerleading has progressed into an extremely acrobatic and physically demanding sport. Since the addition of Title IX, female participation in athletics has skyrocketed. As a result, frequency and severity of injury, as well as the incidence of catastrophic injury in female athletes, has dramatically increased. Cheerleading has continued to be modernized with the addition of activities such as partner stunts and pyramids. In response to higher injury rates, possibly from performing riskier and more physically demanding stunts, the American Association of Cheerleading Coaches and Administrators (AACCA) was organized, and the group was responsible for creating the Cheerleading Safety Standards in 1987. The rules and regulations for the safety of cheerleaders need to continue to expand based on the statistical data gathered on injury type as well as the intensity and extreme level of athletic demands of the progressing sport. As cheerleading continues to grow and evolve, it will be necessary for clinicians and practitioners to better understand the biomechanics of cheerleading and the mechanisms of injury in order to prevent and treat these athletes properly.

A single case study will be discussed throughout this paper (Appendix B). This cheerleader is a professional cheerleader, who formerly competed at the collegiate level. This subject was chosen because the athlete incurred a severe injury resulting from a fall during a cheerleading stunt. This paper will incorporate information from the case study in order to support evidence gathered during the investigation of competitive cheerleading that will hopefully make cheerleading safer yet more competitive.
Competitive Cheerleading Categories

Competitive cheerleading is scored in different categories including: stunts, pyramids, and jumps. Stunts are when one or more cheerleaders support other cheerleaders, who are lifted off of the ground. Pyramids require partners that are in contact with each other while performing a stunt. Jumps are usually performed with a preparatory phase, where the athlete squats with their arms down by their side and then rises explosively while swinging the arms upward and jumping. There are many variations and types of jumps. It can be speculated that because these categories require more athletic ability, the risk of injury has also increased for cheerleaders.

Biomechanics

Cheerleading is an extremely complex sport and can involve a never-ending list of various stunts, jumps, pyramids, dances, and cheers which incorporate a number of different movements. Three main cheerleading positions exist: base, partner, and spotter. These positions are all included in performing stunts, the aspect of cheerleading that has the highest risk for injury.

Spotter

The first position that will be explored is the spotter (Figure 1). Spotters (i.e. cheerleaders) have one main goal: to make sure that the partner completes their stunt safely. Spotters must be used during stunts where the base (i.e. cheerleader) is required to extend their arms above their head. The spotter needs to protect the partner’s head, neck, and spinal cord and additionally slow their partner’s speed down as they approach the ground in order to control their safe landing. The spotter provides extra support and stability for the partner performing the stunt.
Four Corner Spotting Technique

Spotting makes use of eccentric strength, when the spotter makes contact with the partner to reduce the partner’s speed for a safe landing. The spotter must also have great kinesthetic awareness. If the spotter’s torso ends up directly underneath the partner, the partner may fall over the spotter’s head and be injured. The main components of spotting correctly are:

- Maintain focus on the stunt
- Remain alert
- Keep eyes on the partner
- Stay in proper position to catch the partner
- Reach up high with the fingertips
• Make contact with the partner
• Bring the partner in close to the body
• Use eccentric strength to reduce the partner’s speed during landing
• Control the stunt by keeping hands on the partner if possible
• Keep the partner’s feet close together

  Clear communication with designated commands between the partner and the spotter are imperative when performing stunts in order to alert the other person to adjust their body position. The spotter is usually the athlete in charge of the counting process that initiates the stunt.

Finally, it is also very important for basic spotting drills to be performed repeatedly and consistently before more complex maneuvers are attempted.6

**Base**

The second position that is incorporated into a stunt is the base (Figure 2). Usually, two bases (i.e. cheerleaders) are used while performing stunts, but sometimes, most commonly with male cheerleaders, a single base might be used.6 The base provides a solid, foundation of support for their partner. An additional responsibility for the base is that they must catch the cheerleader performing the stunt during the dismount phase. Timing is a crucial factor in basing during a stunt.6 If there are two bases, they must lock their arms and legs in perfect synchronicity in order to effectively complete the stunt.
Bases

Figure 2. The arrows indicate bases.

The main biomechanics associated with base includes:

- Keeping the head and chest up with back straight
- The feet should be positioned shoulder width apart in a double lunge position with feet set and angled outward
- Arms are kept close to the body with cupped hands near the umbilicus if preparing for a lift
- The muscles of the lower extremities are used eccentrically and then have a high rate of force production during the lift
• If more than one base is utilized, they should remain at a shoulders width distance during the execution of the stunt
• The arms are fully extended
• The knees are slightly bent to provide “cushion” during the dismount and absorb shock
• The partner should be caught high

The base acts as the foundation for lifts and pyramids, and the athlete that fills this position must be able to perform stable isometric contractions to control the lift. For example, in the lower extremity, the quadriceps and hamstrings act isometrically at the knee joint as well as at the hip joint with the iliopsoas and gluteus maximus; the gastrocnemius and soleus act isometrically with the tibialis anterior at the ankle joint; and the abdominal musculature acts isometrically with the erector spinae.

**Partner**

The third position in a stunting group is the partner (Figure 3). The partner is the cheerleader that is being supported by the base(s) and is at the apex of the stunt. The partner has to focus on performing the stunt with their body rigid and controlled, to climb as lightly as possible, and to use correct timing and weight transfer in order to allow the base to properly support them. The partner position must be an athlete who has good body awareness, strength, and control over their body. The proper technique for the partner in a stunt includes:

• Using the arms to push off the base’s shoulders in order to build the stunt
• Stepping, extending, and tightening the legs while climbing
• Keeping the feet close together when climbing
• Pulling up and keeping the body rigid with the hips up
• Keeping the shoulders, hips, knees, and ankles in a proper alignment
Partner

As the partner climbs, her wrists (flexor carpi ulnaris and radialis) flex concentrically from an extended position, the elbows extend from a flexed position concentrically contracting the triceps brachii, and the shoulder moves in the direction of extension to activate the latissimus dorsi concentrically. In addition, biomechanics associated with the following specific stunts may play a role in injury prevention.

Biomechanics of Specific Stunts

This section contains information about biomechanics associated with specific stunts. These stunts identified have all been noted as having high incidence of injury during performance. These stunts included the cradle, single-based stunts, and pyramids. Also included are some of the more common mistakes that happen when performing the specific stunts based on the cheerleader’s position: base, spotter, or partner.
The Cradle

During the cradle stunt (Figure 4), the job of the base is to generate power mainly from the lower extremities and throw the partner into the air. Their hips extend, activating the quadriceps muscles concentrically. The gluteus maximus contracts, and the ankles are plantar flexed, engaging gastrocnemius/soleus concentrically as well. As the bases throw the partner into the air, they follow through with their upper extremities, pushing them up, and overhead. They catch the partner as high as possible, and immediately begin to decelerate her, flexing the hips and knees progressively to absorb the shock as she comes down. The bases’ hips and knees flex, and the ankles dorsiflex eccentrically engaging the quadriceps, iliopsoas, gluteus maximus, gastroc/soleus during the catch.

The bases’ hands should be positioned under the partner’s legs and behind the thoracic spine, bringing the partner in close as they catch her. The bases should also focus on maintaining an erect spine and remain as close as possible during the cradle stunt. The spotter helps the bases catch the partner, supporting her under the arms to protect her head, neck, and spine. The partner must keep their body rigid and keep the knees extended and ankles plantar flexed. She will need to raise her upper extremities into a “T” on the way up and lift her lower extremities to a “pike position” when her body returns to the starting position. As the partner approaches the catching phase of the cradle, she should wrap her arms around the bases’ shoulders. With multiple cheerleaders involved in the stunt, when one person doesn’t perform the stunt correctly, it puts the other cheerleaders at risk for injury. For a detailed description of the biomechanics during the cradle, see Appendix A. The most common mishaps when performing the cradle are:

- Kneeing the partner in the back
• Catching the partner’s head and back low to the ground
• Bases hitting each other’s heads
• Allowing the partner’s feet to hit the ground

Cradle Stunt

Figure 4. The cheerleaders are performing cradle stunt.

**Single-based Shoulder Stand**

For the single-based shoulder stand (Figure 5), the partner begins by standing behind the base. They should reach up and grab onto the base’s hands with a handshake style of grip. The partner will then push against the base’s hands as they step into the pocket area, or superior aspect of the thigh where it meets the hip, extending their leg. The partner will use their contralateral foot to step close to the base’s neck on the shoulder. As the partner continues to push into the base’s hands, they will step onto the other shoulder with the initial foot. Both of
the partner’s legs should be extended at this time, as they release the base’s hands, one at a time, maintaining a rigid posture. At this point in the stunt, the partner will be standing fully erect and bring the upper extremities up into a tight “V”. When the partner is ready to dismount, they should flex at the hips, grab onto the base’s hands, once again using a handshake grip, and step off.

Single-based Shoulder Stand

![Single-based Shoulder Stand](image)

Figure 5. The cheerleaders are performing single-based shoulder stand with spotter.

During the single-based shoulder stand, the base begins by standing in a double lunge position with the shoulders facing towards the front. The next step in the stunt is for the base to fully flex the shoulders and extend the elbows, reaching over their head and lock hands with the partner with the handshake grip. As the partner steps onto the base’s hip and then shoulder, the base pushes up with the hands. This requires isometric contractions of the biceps brachii and triceps brachii to maintain full extension of the elbows. The shoulders are also isometrically contracted in a fully flexed position overhead, with the deltoids, pectoralis, and latissimus
muscles engaged. While the partner steps their second foot onto the other shoulder, the base stands all the way up, keeping her feet shoulder width apart for balance. The partner releases one hand at a time, and as she does, the base grabs around the partner’s calves to provide additional support. During the dismount phase of this stunt, the base grasps the partner’s hands with a handshake grip again. The partner steps off forward. The base pushes into the partner’s hands to decelerate the partner as she approaches the ground.9

Two of the more significant challenges that occur during performance of the single-based shoulder stunt are the partner falling backward or the partner not being able to get both feet onto the base’s shoulders. Once again, these are the times when injuries can potentially occur.9 A spotter may be used for this stunt until it has been mastered by both the base and partner. The spotter’s role is to support the partner at the waist during the climb, support the lower extremities during the stunt, and shift to the side during the dismount to support her at the waist.9

In the event of the case subject, the athlete suffered a severe injury while performing the single-based shoulder stand. The athlete performing the stunt fell backwards when she reached the top of the base’s shoulders. When she landed on her back, her head hit the floor, and her momentum carried her legs over her head. The impact resulted in a concussion, two fractured ribs, three fractured vertebrae (T11, T12, L1), and damage to surrounding muscles and ligaments. An additional issue for this athlete was that there was no spotter used during the performance of the stunt. Utilizing a spotter during the stunt might have prevented the athlete from falling and receiving the resultant injuries.

The Pyramid

Once other stunts have been mastered, they can be put together to compose a pyramid (Figure 6).9 There are a few issues that should be considered for building a pyramid safely.
Communication is very important, and typically a spotter positioned near the middle of the pyramid counts loudly to maintain the crucial synchronization of the stunt. Defining the roles of each athlete performing a pyramid is also imperative. Each cheerleader must know their exact part within the pyramid and perform her task(s) correctly. The basic components of the individual roles are separated by each position.

Pyramid Stunt

Figure 6. The cheerleaders are performing pyramid stunt.

The bases must not get too close to each other that they hit or get tangled, but they need to remain close enough for their partners to use them to brace. Incidentally, the average weight of a partner for collegiate level cheerleading is 115 pounds, meaning that each base would need to be able to support approximately 58 pounds during a two person pyramid.\(^\text{10}\) This would average about 86 pounds of support per base during a three person pyramid. Each base, similar to each athlete involved, must maintain synchronization to the correct counts that are provided. The bases also have additional responsibilities in regards to catching the partners as they perform their dismount. As previously described, the partners must also maintain appropriate body
mechanics as they climb. Partners can also be used as bases for another tier, which involves additional partners depending on the level of the cheerleaders. Lastly, the spotters’ roles are to properly position themselves to catch partners, be prepared to step in and stabilize the pyramid if something goes wrong, and use a hands-on technique to add more support and strength to the pyramid.9

Injuries

The most common injuries of high school and collegiate cheerleaders are:8

- Strains and sprains of the ankle and neck
- Abrasions, contusions, and hematomas
- Concussions and closed head injuries
- Fractures and dislocations
- Lacerations or punctures

The anatomical regions of the body with the highest incident of injury for collegiate cheerleaders are:8

- Trunk
- Lower extremities
- Upper extremities
- Head
- Face
- Neck

The anatomical regions of the body with the highest incident of injury for high school cheerleaders are listed below:8

- Trunk
• Lower extremities
• Upper extremities
• Face
• Neck
• Head

*Note: Sprains and strains typically affect the ankle and neck, normally resulting from a fall; and knee and low back injuries tend to occur when spotting.

**Mechanism of Injury**

The majority of injuries that have occurred for cheerleaders at the high school and collegiate level have been as a result of the following:

• Catching another cheerleader
• Falling
• Making contact with another cheerleader
• Failing to complete a maneuver
• Lifting or tossing another cheerleader
• Twisting a body part
• Improper execution of a maneuver
• Spotting or basing another cheerleader

All of these injuries have transpired as a result of attempting various stunts. The most common types of stunts being performed when an injury occurred were the cradle and single-leg stunt, pyramid, single-based stunt, elevator (also known as a sponge toss), extension, stunt-cradle combo, transition, and miscellaneous stunts including the partner or group stunt. The incident that occurred with the subject in the case study suggests that the statistical evidence provided on
Injuries is very similar to that involved with the professional cheerleader both related to the type of stunt being performed and the injured area of the body.\(^8\)

In order to promote injury prevention, a strong emphasis should be placed on biomechanics, coaching proper execution of the stunts, and safe methods to spot another cheerleader performing a stunt. It is also important that professionals are adequately educated on injury prevention and techniques for performing stunts safely.

In addition, other factors for injury prevention include increasing cardiovascular fitness, promoting flexibility, and establishing a higher muscular fitness level in cheerleaders.\(^9\) Another ideology of injury prevention is that a cheerleader should master a stunt by completing it technically correct ten times in a row before performing the task for competitive purposes.\(^9\) Stunts should also be practiced on an appropriate surface and in a suitable environment based on the coach’s knowledge and experience. Technical skills should not be performed on asphalt, concrete, wet, or uneven surfaces.\(^6\) Although repetition and perfection of stunts during practice reduces the incidence of injury, it does not prevent every injury from occurring. The professional cheerleader identified in the case study reported performing the single-based shoulder stand thousands of times during her career and several times during each practice. Despite the experience level and the number of repetitions that she had performed the stunt, she still suffered a severe injury from attempting the stunt.

**Catastrophic Injuries**

Cheerleading has been deemed one of the most dangerous female sports.\(^2\) The drastic increase in the number of injuries since its inception should been enough evidence to create a concern among the professionals who train and also treat cheerleading injuries.\(^11\)
In 1980, according to the Consumer Product Safety Commission, emergency room visits by cheerleaders were 4,954. However, the number of emergency room visits in 2004 had skyrocketed 474% to 28,414. In 2008, 112 direct catastrophic injuries were reported, 56 were high school cheerleaders and 44 were collegiate cheerleaders. By 2011, the rates had increased to 62 events for high school cheerleaders and 51 events for collegiate cheerleaders. These were 11% and 16% increases in catastrophic injury rates respectively. The total catastrophic injuries between 1982 and 2008 for specific high school and collegiate sports are identified in Table 1.

From 1982 to 2008, the percentage of catastrophic injuries that were attributed to competitive cheerleading was 70.5% for female collegiate athletes and 65.2% for female high school athletes. A majority of catastrophic head injuries occurred when athletes performed pyramids and basket tosses. Basket tosses are performed by two individuals performing as bases tossing a partner into the air while their hands are interlocked, and pyramids are stunts in which the partners are connected. Pyramids require bases, partners, and spotters to complete the stunt, making them much more complex stunts, which potentially put an athlete more at risk for catastrophic injury.
Table 1. Total Catastrophic Injuries from 1982-2008 for High School and Collegiate Athletes\textsuperscript{12}

![Total Catastrophic Injuries 1982-2008]

Most Common Injuries, Rehabilitation, and Prevention

**Ankle Sprain and Rehabilitation**

A sprain is overstretching or tearing of ligaments surrounding a joint. Most sprains are characterized by pain, swelling, bruising, and the loss of functional ability. Sometimes, the athlete can feel or hear a popping or tearing when the injury occurs.\textsuperscript{17} Ankle sprains are graded I, II, or III based on severity of the injury as displayed below in Table 2.\textsuperscript{18}
Table 2. Grading System for Ankle Sprains\textsuperscript{18}

<table>
<thead>
<tr>
<th>Grade</th>
<th>Characteristics</th>
</tr>
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</table>
| Grade I | • Mild stretching of the involved ligament with minimal swelling and point tenderness  
*Note: The anterior talofibular ligament is the most commonly involved.* |
| Grade II | • May exhibit mild to moderate levels of instability  
• Involves partial or complete tearing of the anterior talofibular ligament as well as the calcaneofibular ligament  
• Localized swelling at the injury site |
| Grade III | • Severe instability  
• Complete tearing of both the anterior talofibular ligament and the calcaneofibular ligament  
• Complete tearing of the anterior portion of the capsule  
• Swelling on both sides of the Achilles tendon  
• Tenderness on both the medial and lateral ankle |

The preferred method of treatment for an ankle sprain is functional rehabilitation.\textsuperscript{17} Functional rehabilitation allows an athlete to return to physical activity and participation faster than immobilization. It has also been associated with fewer ongoing symptoms such as muscle weakness, stiffness, pain, and instability. The phases of rehabilitation for ankle sprains as well as the focus of treatment and accepted therapeutic activities for each phase are listed below in Table 3.
Table 3. Phases of Ankle Sprain Rehabilitation and Accepted Therapeutic Activities

<table>
<thead>
<tr>
<th>Phase</th>
<th>Focus of treatment</th>
<th>Accepted therapeutic activities</th>
</tr>
</thead>
</table>
| Acute   | During this phase, the focus is on reducing swelling, pain, inflammation, and hemorrhage. The athlete should also bear weight as tolerated. | • PRICE: protection, rest, ice, compression, elevation  
  • Immobilization: Although prolonged immobilization is contraindicated, during the acute phase, immobilization may be necessary depending on the severity of the injury.  
  o Grade I Sprain: 1-3 days: ankle brace  
  o Grade II Sprain: 2-4 days: ankle brace  
  o Grade III Sprain: 3-7 days: boot/cast for more stability, protection, and support  
    ▪ A boot can also allow the athlete to weight bear sooner and with reduced pain.  
    ▪ For a grade III sprain, use of an immobilizer can be continued for up to three weeks. With improvement, the athlete can switch from the boot to a brace. |
| Subacute| During this phase, the focus is not only on continuation of reduction of pain, inflammation, and swelling, but also on initiation of movement, strengthening, and controlled weight-bearing on the affected lower extremity. | • Grade I Sprain: 2-4 days  
  • Grade II Sprain: 3-5 days  
  • Grade III Sprain: 4-8 days  
  o Active range of motion exercises such as:  
    ▪ Dorsiflexion, Inversion, Eversion, Plantar Flexion  
    ▪ Foot circles or alphabet  
  o Strengthening:  
    ▪ Isometric exercises can be done as long as it is within a pain-free range for the athlete  
    ▪ Toe curls with a towel or picking up objects with toes  
  o Proprioceptive training:  
    ▪ Biomechanical Ankle Platform System (BAPS board) while seated  
    ▪ Wobble board  
    ▪ Ankle disk  
  o Stretching:  
    ▪ Passive ROM: dorsiflexion and plantar flexion in pain-free range, NO inversion or eversion  
    ▪ Gentle stretching of the Achilles tendon  
    ▪ Grades I and II joint mobilizations for dorsiflexion and plantar flexion |
Table 3 (Continued)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Focus of treatment</th>
<th>Accepted therapeutic activities</th>
</tr>
</thead>
</table>
| Rehabilitative | During this phase, the goals are increasing pain-free range of motion, continue and progress strengthening, and progress proprioceptive training to more difficult tasks. The patient should be at the level of full weight-bearing without antalgic gait. Modalities can continue to be utilized, especially after the above exercises in order to prevent pain and swelling. The athlete may also continue using various methods of supportive bracing or taping. | - Grade I Sprain: 1 week  
- Grade II Sprain: 2 weeks  
- Grade III Sprain: 3 weeks  
  - Stretching  
    - Gastrocnemius and soleus  
    - Joint mobilization can now be taken to a grade III mobilization. Eversion can also be done at this time; however, continue to avoid inversion.  
  - Strengthening: Initiate weight-bearing exercises such as:  
    - Heel raises  
    - Toe raises  
    - Stairs  
    - Mini-squats  
  - Eccentric/Concentric Exercises and Isotonics: The athlete can use TheraBand or cuff weights.  
    - Inversion, Eversion, Plantar Flexion, Dorsiflexion  
    - Peroneal strengthening  
    - Isokinetics  
  - Proprioceptive training: The athlete should now begin full weight-bearing during this training.  
    - Standing on the BAPS board, wobble board, etc.  
    - Single-leg balance activities can be performed on both stable and unstable surfaces |
Table 3 (continued)

<table>
<thead>
<tr>
<th>Phase</th>
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<th>Accepted therapeutic activities</th>
</tr>
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</table>
| Return to activity    | During this phase, the athlete should begin to regain full strength of the lower extremity musculature. They should be able to use normal biomechanics during play with no compensation. The demands on the ankle musculature vary depending on the athlete’s position. For example, a base would need stability of the ankle musculature in order to maintain isometric contraction when creating a foundation for lifts. They would also need explosive strength for plantar flexion and eccentric strength to perform the catch effectively. They should be returning to competition, and they should continue to strengthen and protect the joint. | • Grade I Sprain: 1-2 weeks  
• Grade II Sprain: 2-3 weeks  
• Grade III Sprain: 3-6 weeks  
• Continue to progress range of motion and strengthening exercises to make them more challenging.  
• Sport specific strengthening and training should be integrated at this time.  
• The athlete should start running again. Perform all of these on smooth, stable, flat surfaces.  
  o Jog-walk-jog  
  o Sprint-jog-sprint  
  o Figure 8s  
  o Zig-zags  
• Agility drills can be integrated:  
  o Back pedaling  
  o Side stepping  
  o Carioca  
• Sport Specific Plyometrics  
• Use multidirectional balance and movement patterns                                                                                                                                                                                                                                                                                                                                                     |
| Return to competition | When the athlete can perform all of the skills listed above at full speed, they should be allowed to return to practice. If the athlete can tolerate an entire practice, then they can return to competition.                                                                                      | • Continue to use a brace for protection and added stability for the rest of the season.  
• The healthcare professional may want to observe the cheerleader performing basic cheerleading skills depending on their position before returning to competition.  
• They could require them to perform all jumps, stunts, and lifts that would be required in competition in a safe environment with plenty of spotters and appropriate flooring before moving on to competition.                                                                                                                                                 |
Table 3 (Continued)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Focus of treatment</th>
<th>Accepted therapeutic activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prophylactic</td>
<td>During this phase, the goal is to prevent injury.</td>
<td>• Functional drills</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Multidirectional balance board activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Strengthening (with emphasis on eversion)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Use supportive braces as needed</td>
</tr>
</tbody>
</table>

**Injury Prevention Program via Balance Training for Ankle Sprains**

Balance training can be used as a means to reduce the incidence of ankle sprains. The following program (Table 4) has resulted in a 38% decrease in rate of injury among the group of athletes who performed the five stage balance training program. With ankle sprains being one of the most prominent injuries incurred during athletic competition, including cheerleading, this type of balance training program seems like a potentially effective method of injury prevention. Balance training has also been incorporated in the case study as a suggested additional recommendation for injury prevention for cheerleaders at the professional level. Stages I through IV should be performed five days per week for a one week time period. Stage I should be initiated during the off-season. Each athlete should progress through the program as previously indicated. By the time the athletes reach the preseason and in-season mesocycles, they should be performing Stage V of the program. Stage V should be continued three days per week for the remainder of the athletic season. Each exercise should be performed for 30 seconds per leg with a 30 second rest period between each repetition. The full program is listed below (Table 4).
Table 4. Ankle Sprain Prevention Program\textsuperscript{19}

<table>
<thead>
<tr>
<th>Phase</th>
<th>Surface</th>
<th>Eyes</th>
<th>Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I</td>
<td>Floor</td>
<td>Open</td>
<td>Single-leg stance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open</td>
<td>Single-leg stance while swinging raised leg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open</td>
<td>Single-leg squat to 30-45 degrees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open</td>
<td>Single-leg stance with functional activity</td>
</tr>
<tr>
<td>Stage II</td>
<td>Floor</td>
<td>Closed</td>
<td>Single-leg stance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Closed</td>
<td>Single-leg stance while swinging raised leg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Closed</td>
<td>Single-leg squat to 30-45 degrees</td>
</tr>
<tr>
<td>Stage III</td>
<td>Balance Board</td>
<td>Open</td>
<td>Single-leg stance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open</td>
<td>Single-leg stance while swinging raised leg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open</td>
<td>Single-leg squat to 30-45 degrees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open</td>
<td>Double leg stance while rotating the board</td>
</tr>
<tr>
<td>Stage IV</td>
<td>Balance Board</td>
<td>Closed</td>
<td>Single-leg stance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open</td>
<td>Single-leg stance while swinging raised leg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open</td>
<td>Single-leg squat to 30-45 degrees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open</td>
<td>Single-leg stance while rotating the board</td>
</tr>
<tr>
<td>Stage V</td>
<td>Balance Board</td>
<td>Closed</td>
<td>Single-leg stance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open</td>
<td>Single-leg squat to 30-45 degrees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open</td>
<td>Single-leg stance while rotating the board</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open</td>
<td>Single-leg stance with functional activities</td>
</tr>
</tbody>
</table>

Figure 7. Single-leg stance on floor with eyes open (Stage I)
Neck strains and sprains, occurring as a result of falling, are also common injuries in competitive cheerleading.\textsuperscript{8} Neck sprains and strains are usually a result of trauma.\textsuperscript{20} Some of the traumas that can precipitate a neck sprain or strain can be an extension injury, a flexion injury, or whiplash. Whiplash injuries are graded according to the Quebec Task Force Classification Scheme for Whiplash-Associated Disorders (WAD) listed in Table 5. An extension injury can happen in the cervical spine if the head rapidly accelerates into an extended position and nothing
stops the motion. When this happens, the posterior structures of the cervical spine are compressed and the anterior portions including the musculature and ligaments are stretched. This also puts stress on the temperomandibular joint and muscles responsible for opening and closing the jaw. A flexion injury occurs in the opposite direction with the head accelerating forward without being stopped until the chin is stopped by the sternum. The mandible is then pushed posteriorly, compromising the temperomandibular joint and the posterior cervical musculature, ligaments, fascia, and joint capsules are stretched.\textsuperscript{20}

There are three phases of movement during a whiplash injury, which includes both flexion and extension.\textsuperscript{21} In the first phase, the lower cervical spine segments extend, while the segments above are forward flexed. In the second phase, all of the cervical segments are extended. In the third phase, the movement mimics the first phase with maximal flexion of the higher segments during this time.

Table 5. Quebec Task Force Classification Scheme for Whiplash-Associated Disorders (WAD)\textsuperscript{22}

<table>
<thead>
<tr>
<th>Grade</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| Grade 0 | • No complaint of neck pain  
|         | • No physical signs of pathology |
| Grade I | • Complaint of pain, stiffness, or tenderness  
|         | • No physical signs indicating pathology |
| Grade II | • Complaint of neck pain, stiffness, and tenderness  
|          | • Musculoskeletal signs of pathology including decreased range of motion and point tenderness |
| Grade III | • Complaint of pain, stiffness, and tenderness  
|           | • Presence of neurological symptoms, including decreased or absent deep tendon reflexes, muscle weakness, and sensory deficits |
| Grade IV | • Neck complaints as well as a fracture or dislocation (most severe) |

The symptoms of a neck sprain or strain can include neck pain and associated upper extremity pain or referred pain to the upper extremity.\textsuperscript{23} These symptoms may be present for a substantial amount of time and are precipitated by some sort of trauma or whiplash injury. Other
Impairments may include pain in midrange of the athlete’s range of motion that gets worse at end range; strength, endurance, and coordination deficits of the deep muscle flexors; provocation of neck and associated upper extremity symptoms with aggravation of the involved cervical segments; cervical instability; and muscle spasms surrounding the involved cervical segments. Interventions for neck sprains and strains should include stretching, strengthening, coordination, and endurance exercises. Patient education about the injury and rehabilitation process should be included in their plan of care. The following is a protocol for treatment of neck sprain or strain (Table 6).
Neck Sprain/Strain and Rehabilitation

Table 6. Phases of Neck Rehabilitation, Focus of Treatment, and Accepted Therapeutic Activities

<table>
<thead>
<tr>
<th>Phase</th>
<th>Focus of treatment</th>
<th>Accepted Therapeutic Activities</th>
</tr>
</thead>
</table>
| Acute | • Primary goal is protection  
• Pain and inflammation control | • Modalities such as ice and electrical stimulation can be used for the control of pain and inflammation. Support may be necessary in order to give the cervical muscles some relief from supporting the head. Cervical collars are a good way to support the cervical spine in addition to limiting painful motion. These collars are worn depending on the severity of the injury.  
• If there are any muscles in spasm, the practitioner can use a contract relax stretch technique applying only very light resistance with the muscle that is guarding beginning in the most shortened position. The muscle should be slowly and progressively lengthened. Reverse muscle action can also be used. When actively moving the cervical spine causes pain for the athlete, the athlete can actively engage scapular and shoulder musculature by contracting and holding and then being cued to relax. If simply contracting and relaxing these muscles in the form of scapular elevation, depression, rotation, and adduction does not exacerbate symptoms.  
• The athlete can progress by performing an active movement at the shoulder including flexion, extension, abduction, adduction, and rotation. By performing these movements at the shoulder and scapula, the cervical musculature is forced to stabilize the cervical spine. |
<table>
<thead>
<tr>
<th>Phase</th>
<th>Focus of treatment</th>
<th>Accepted Therapeutic Activities</th>
</tr>
</thead>
</table>
| Subacute      | • Controlling motion of the cervical spine, posture, strength, and mobility         | • Practice awareness and control of spinal alignment and posture. The athlete can actively perform multidirectional movements in pain-free ranges.  
  o Head nods and chin tucks  
• Joint mobilizations or manipulation can be done in addition to self and assisted stretching to increase mobility in any tight structures such as muscles, joints, or fascia.  
• Practice stabilization exercises and progress them based off of athlete’s tolerance. The athlete should begin to increase repetitions in order to build up endurance.  
  o Core strengthening for the cervical spine includes performance of head nods and flattening of the cervical lordosis in the supine position. This targets the multifidi and longus colli muscles.  
• The athlete should begin to perform low to moderate intensity aerobic exercise.  
• The athlete should be educated on proper posture and biomechanics and practice functional tasks such as reaching for objects, pushing, pulling, and lifting.  
• Upper extremity strengthening and core strengthening can be done as well.  
  o Core strengthening for the cervical spine includes performance of head nods and flattening of the cervical lordosis in the supine position. This targets the multifidi and longus colli muscles. |
| Return to activity | • Beginning high intensity, repetitive activities that require spinal control | • Joint mobilization, manipulation, and stretching can be continued to facilitate improvements in range of motion.  
Progress strengthening exercises for the cervical spine as well as the extremities emphasizing functional movement.  
  o Increase aerobic activity intensity.  
  o Educate the athlete on postures and positions that relieve stress.  
  o Begin activity specific training, and incorporate cervical control, endurance, timing, and speed. |
Cervical Spine Strengthening and Injury Prevention

Strengthening of the cervical spine musculature has been performed in order to reduce incidence of injury among rugby players. A majority of injuries that occur to the cervical spine during this sport are due to trauma from contact with another player or contact with the ground. This is similar to cheerleading. Neck injuries that occur during competitive cheerleading are also associated with contact with another player or the ground. The subject in the case study did not incur a cervical injury during her fall; however, when the athlete’s back hit the floor, momentum continued and caused her neck to extend forcefully. Her head hit the ground, and she suffered a concussion. Hypothetically, had the athlete been performing a cervical spine strengthening program, she may have been capable of reducing the force at which her head impacted the ground and possibly decreased the possibility of concussion.

In research conducted on football players, the incidence of injury was lower amongst athletes who had stronger cervical and shoulder musculature and increased muscle mass in this area. As with many of the other injuries that have been discussed, incidence of injury for the cervical spine is also more common late in the competition, when the athlete is experiencing muscular fatigue. Strengthening the neck, upper traps, shoulder, and middle back musculature could significantly reduce risk of injury with a program such as seen in Table 7. Since the neck muscles act to stabilize the cervical spine during a fall or contact with another person, isometric exercises are suggested to not only increase strength but to improve cervical stabilization. It is important not to perform any strengthening exercises at end or extreme ranges of motion because it can cause excessive degeneration of the facet joints and intervertebral discs.
Table 7. Frounfelter Strengthening Program^{24}

| Isometrics (seated or standing) | o With one hand applying pressure to the left side of the head, the athlete maintains a neutral cervical spine by resisting the pressure in the opposite direction. Hold for 5-10 seconds. Repeat 5 times. Repeat this exercise forward, backward, to the left, and to the right. |
| Wall bridging | o The only points of contact for the athlete are the head and the feet. A towel is placed between the athlete’s forehead and the wall. The athlete maintains a rigid posture while leaning up against the wall. The exercises should be performed twice and held for 30 seconds each time. Repeat for cervical extension and on the left and right sides for lateral flexion. |
| Other exercises | o Upper trapezius muscles
  - Shrugs
  - Upright rows |
| Shoulder girdle | o Shoulder girdle
  - Bench press
  - Rows
  - Over-head presses
  - Dips
  o With these exercises, the athlete should keep muscular balance in mind. For example, if they perform an exercise for the chest, they should do one of equal intensity and repetitions for the back. |

*When the athlete can perform 10 repetitions of 10-30 seconds of each exercise, they may progress to the next exercise.*
These exercises should be incorporated into each athlete’s resistance training program. The athletes can begin the isometric neck exercises during the off-season and progress as indicated in the program. By the time the athletes reach the preseason mesocycle, they should be performing wall or floor bridging. During the in-season mesocycle, the athletes should be incorporating other exercises such as shrugs and upright rows. Appendix D displays where these exercises should be incorporated into the periodization program.
**Concussion**

Concussions are another common injury that cheerleaders incur.\(^8\) Concussions can be associated with both short term and long term complications for the athlete.\(^{25}\) A cerebral concussion is a form of traumatic brain injury caused by a bump, blow, or jolt to the head\(^{25}\) or to another area of the body with a resulting impulsive force transferred to the head.\(^{26}\) A concussion has a rapid onset of neurologic impairment that usually resolves spontaneously and relatively quickly.\(^{26}\) Acute symptoms of concussion typically are reflected with functional impairment rather than structural injury. Other symptoms include dizziness, irritability, fatigue, loss of consciousness, headache, seizures, balance or vision problems, light or noise sensitivity, confusion, and amnesia. Concussion also has other symptoms that can include visual disturbances, loss of equilibrium, and possible impairment of neural function.\(^{17}\)

**Rehabilitation and Return to Play Protocol**

After a concussion the athlete should rest both physically and cognitively.\(^{26}\) This means that they should not only avoid any physical activity, but they should also refrain from working or going to school. Most concussions (i.e. 80 to 90%) resolve within seven to ten days.\(^{26}\) Once the athlete is asymptomatic for 24-hours following rest, they should be reevaluated. Once they are cleared, they can return to life, work, and school as usual with the exception of performance of physical activity/exercise. They can also begin the return to competition protocol that is listed in Table 8 below.\(^{26}\) Table 8 is a new cheerleader-specific return to play protocol introduced by the AACCA.

There must be 24-hours allotted before progressing to the next stage. If during any of the rehabilitation stages the athlete has symptoms, they should stop the activity and rest. After they
have rested and been symptom-free for 24-hours, they can return to the previous asymptomatic stage of the rehabilitation process. The process is designed to take about seven days.

Table 8. Stages of Concussion Rehabilitation with Suggested Activities and Goals

<table>
<thead>
<tr>
<th>Stage</th>
<th>Activity</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1: No activity</td>
<td>Physical and cognitive rest</td>
<td>Rest and recovery</td>
</tr>
<tr>
<td>Stage 2: Light aerobic exercise</td>
<td>Walk, swim, stationary cycle At &lt;70% Mean Predicted Heart Rate (MPHR) No resistance training allowed</td>
<td>Increase heart rate</td>
</tr>
<tr>
<td>Stage 3: Sport Specific Exercise</td>
<td>Running is now allowed, any sport specific aerobic activity that does not risk contact with the head is also allowed.</td>
<td>Add movement</td>
</tr>
<tr>
<td>Stage 4: Non-contact training drills</td>
<td>Progression to more complex training drills, and the athlete may begin progressive resistance training.</td>
<td>Exercise, coordination, and cognitive restoration</td>
</tr>
<tr>
<td>Stage 5: Full contact practice</td>
<td>Requires medical clearance, but athlete resumes normal training activities.</td>
<td>Restore confidence and assessment of functional skills by coaches</td>
</tr>
<tr>
<td>Stage 6: Return to Play</td>
<td>Normal competition</td>
<td>Resume play</td>
</tr>
</tbody>
</table>
Table 9. AACCA’s Cheerleader-Specific Concussion Rehabilitation

<table>
<thead>
<tr>
<th>Stage of recovery</th>
<th>Accepted therapeutic activities</th>
</tr>
</thead>
</table>
| Stage 1           | • No cheerleading/dance/gymnastics activity  
                     • May do low-level exercise that does not raise the heart rate (walking, slow stationary bike, etc.) |
| Stage 2           | • Continue basic exercise now allowing a slightly raised heart rate (fast walking, stationary bike, slow elliptical, etc.) |
| Stage 3           | • Begin moderate exercise (fast elliptical, slow jogging, light weight lifting, etc.)  
                     • Cheerleading activity remains limited to cheers/chants, but may now introduce quick movements of the head and may introduce mild to moderate dances  
                     • Thigh level stunts are allowed with an added spotter |
| Stage 4           | • Begin low-level cheerleading activities such as basic gymnastics and basic stunting  
                     • Limit stunting to double-legged, chest-level stunts with an added spotter  
                     • Limit gymnastics to single-rotation in a hand-supported position (i.e. cartwheel, round-off, or handspring)  
                     • Minimum of 2-miture break between tumbling passes for a max of 30 minutes total participation  
                     • Sideline cheers permitted but absolutely no live activity or practicing of “competition routines” |
| Stage 5           | • Begin moderate-level cheerleading activities  
                     • Limit stunting to double legged, extension level activities with simple dismounts and an added spotter  
                     • Limit gymnastics to basic and moderate tumbling passes: max of 2 rotations with no twisting per any single pass (i.e. round-off back tuck)  
                     • Minimum of 2-minute break between tumbling passes for a max of 60 minutes total participation  
                     • Absolutely no game cheering or practicing of “competition routines” |
| Return to full competition | • Pending physician approval may begin full participation including advanced stunts, advanced gymnastics, and advanced dances  
                              • May practice, compete, and participate in sideline activities |

**Prevention Strategies for Concussion**

Since problems such as language, thinking, memory, learning, and emotional impairments can continue on for months or longer, it is important to focus on concussion
prevention for competitive athletes. Surveys were sent to roughly a thousand of the coaches who ordered the “Heads Up: Concussions in High School Sports” tool kit through the Center for Disease Control (CDC) during an eleven month time period. The results of the data collected were that the kits provided the coaches with knowledge about concussions, raised their awareness and changed their attitudes about the severity of concussions, enabled them to educate others about concussions, and changed the way they managed or attempted to prevent concussions. Coaches reported that they found the kit to be a valuable resource and they focused more energy on equipment fitting in addition to proper biomechanics during practice and competition to prevent concussions.\textsuperscript{25}

If all competitive cheerleading coaches were given a tool kit such as the one offered by the CDC or if they were required to attend an educational seminar held by a qualified healthcare professional, such as a local physical therapist who is well-versed in the demands of competitive cheerleading as well as the most common injuries, rehabilitation methods, and injury prevention techniques, they could help reduce the risk of concussion amongst their athletes.\textsuperscript{25} In these seminars, the healthcare professional could discuss proper flooring, biomechanics, spotting, and mastery of basic stunts prior to progressing to more complex stunts that would put the athletes at greater risk for injury. Although the case subject was treated immediately by the emergency care staff at the arena, there are times when medical staff will not be present, such as at practices. Even coaches at the professional level should be well versed in signs and symptoms of concussion as well as prevention techniques and return to play protocols.

\textit{Low Back Strains and Sprains}

Trunk and low back injuries are also common injuries experienced by cheerleaders.\textsuperscript{8} Some of the most common reasons for low back pain for athletes include
spondylolysis, which is a defect of the pars interarticularis, sprains and strains. Most injuries among athletes in the lumbar spine tend to be soft tissue related, unless there is trauma involved from an incident such as a fall. In addition, gymnasts tend to incur low back injuries from repetitive motions of extension in the lumbar spine. When an athlete begins practices after a period of inactivity, they are at risk for incurring back injuries due to inadequate strength levels of the erector spinae and abdominal muscles which are spinal stabilizers. An appropriate periodization program could potentially reduce injuries stemming from weakness due to long periods of inactivity. In addition to muscular imbalance or weakness, flexibility of muscles that attach to the pelvis can play a major role in back injury. Hip flexor and hip extensor lengths must be balanced in order to prevent hyperlordosis or hypolordosis of the lumbar spine, which can put the athlete at an increased risk for injury. A sound injury prevention program should include both strengthening and flexibility exercises. Grading of sprains was previously listed in the ankle section. Provided below is the grading system for strains (Table 10). Strains occur when a muscle or tendon is injured and is graded based on severity from an overstretching of the tissue to a complete tear on the scale from grade I to grade III.

Table 10. Grading System for Strains

<table>
<thead>
<tr>
<th>Grade</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| Grade I (Mild) | • Minimal damage to muscle fibers  
• Minor loss of function, if any |
| Grade II (Moderate) | • Contains more extensive damage to muscle fibers but not full rupture of the tissue  
• Moderate to major reflex inhibition |
| Grade III (Severe) | • Contains complete rupture of the tissue  
• No pain on stretch of the tissue  
• Major reflex inhibition |
Lumbar Strains and Sprains and Rehabilitation

The treatment protocol for lumbar spine sprains and strains follows the same guidelines and principles as the treatment listed in the neck section. The following is a brief description of the goals of the phases of treatment during each phase. Management of injury during the acute phase consists of controlling pain and inflammation and protection of the affected area in addition to patient education, demonstration of safe postures, and initiation of exercises which focus on neuromuscular activation and control of core stabilizers. Also included in the acute phase are rest; modalities such as ice and electrical stimulation; and use of an abdominal corset/brace. An example of an exercise which specifically targets lumbar spine stabilizers is abdominal drawing-in. This exercise can be progressed to challenge the athlete as he or she shows improvement. The subacute phase involves athlete education on modulating pain and methods of developing neuromuscular control of the spinal stabilizers, increasing mobility where there is muscle guarding, increasing athlete awareness of posture, education on safe body mechanics, and developing cardiovascular endurance. During the return to function/competition phase, the focus is on spinal control during movement, increasing mobility or maintaining mobility, increasing trunk and extremity strength, coordination, and endurance. The athlete will also move on to performing intense sport specific exercises while practicing proper biomechanics and engaging core stabilizers.

Prevention of Low Back Injury with Core Stability Exercise

The following is a core stability exercise program (Table 1). Before beginning the exercise program, the practitioner should educate the athlete on the anatomy of the core musculature and stress the importance of strengthening and increasing neuromuscular control over the smaller local muscles prior to working on more global muscles. All parameters
including volume and intensity as well as length of time per repetition are listed as suggested in the literature.\textsuperscript{29} The goal of the first set of exercises is to isolate the core muscles from various positions. These exercises should also be incorporated into each cheerleader’s resistance training program. During the off-season, the athletes should begin performing the supine transverse abdominis contractions and follow the progression listed in Table 10. By the preseason, the athletes should progress to quadruped exercises or planks, and during the in-season, the athletes can begin to perform more challenging exercises for the core musculature such as physioball planks.

Table 11. Core Stability Exercise Program\textsuperscript{29}

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Sets and Repetitions</th>
<th>Progression</th>
</tr>
</thead>
</table>
| Supine transverse abdominis (TA) contraction | 30 repetitions 8 second hold each | Once the athlete has mastered contraction of the TA, they can perform the following activities while holding an active contraction of these muscles:  
  - Heel slides  
  - Leg lifts  
  - Bridging  
  - Standing  
  - Standing row  
  - Walking |
| Quadruped exercises                           | 30 repetitions 8 second hold each | All of these exercises are performed while holding the contraction of the TA musculature.  
  - Quadruped alternating arm lifts  
  - Quadruped alternating leg lifts  
  - Quadruped simultaneous alternating opposite arm and leg lifts |
| Exercises targeting the quadratus lumborum and obliques | 30 repetitions 8 second hold each |  
  - Side plank with knees flexed  
  - Side plank with knees extended |
| Additional exercises                          | Parameters based on athlete’s tolerance | The athlete can progress to trunk curls in addition to:  
  - Physioball exercises  
  - Functional sport specific training while practicing proper activation of the core  
  - Muscular endurance training |
Surfaces, Flooring, and Injury Prevention

Most of the injuries in high school and college competitive cheerleaders have happened while performing stunts on traditional foam flooring. However, injuries have also occurred while on surfaces such as artificial turf, concrete, grass, mats, rubberized tracks, spring floors, wood, or linoleum. Although evidence suggests that traditional foam flooring is dangerous, it is difficult to make this distinction without further research specifically exploring floor type.

An additional factor which needs to be examined are the critical heights or the height at or below which injuries are less likely to occur, and flooring. Ground temperature, moisture levels, grass height, and type of flooring all factor into how well the surface is able to absorb impact. Different surfaces have also been related to the Head Injury Criterion, which is a method to determine whether or not a fall-related injury to the head would be life threatening to the subject. The various types of surfaces on which cheerleaders perform (in order of increasing shock absorption capability and followed by their critical heights in feet) are listed in Table 12.
Table 12. Surfaces and Corresponding Critical Heights (ft.)\textsuperscript{30}

<table>
<thead>
<tr>
<th>Surface</th>
<th>Critical Height (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>.5</td>
</tr>
<tr>
<td>Vinyl tile</td>
<td>.5</td>
</tr>
<tr>
<td>Carpet</td>
<td>1.0</td>
</tr>
<tr>
<td>Asphalt</td>
<td>1.0</td>
</tr>
<tr>
<td>Rubberized track</td>
<td>1.5</td>
</tr>
<tr>
<td>Dry dirt</td>
<td>2.0</td>
</tr>
<tr>
<td>Dry grass (2 inches tall)</td>
<td>3.5</td>
</tr>
<tr>
<td>Artificial turf</td>
<td>4.0</td>
</tr>
<tr>
<td>Traditional foam floor</td>
<td>4.0</td>
</tr>
<tr>
<td>Wood gym floor</td>
<td>4.5</td>
</tr>
<tr>
<td>Dry grass (4 inches tall)</td>
<td>4.5</td>
</tr>
<tr>
<td>Landing mat on vinyl tile</td>
<td>6.5</td>
</tr>
<tr>
<td>Landing mat on foam floor</td>
<td>10.5</td>
</tr>
<tr>
<td>Spring floor</td>
<td>11.0</td>
</tr>
</tbody>
</table>

It has been suggested that the majority of cheerleading injuries can be reduced by either limiting the heights of stunts when performing on certain types of flooring, or changing the type of flooring used when intending to perform a stunt of a particular height based off of the critical heights listed above.\textsuperscript{30} The “AACCA College Safety Rules” contains regulations for college cheerleaders about types of flooring that technical skills should not be performed on and included wet flooring, concrete, or obstructed surfaces.\textsuperscript{31} Also, there are rules for pyramids being
no more than two persons high for high school athletes or two and a half body lengths for collegiate athletes no matter what the flooring type is. In addition, rules are also in place that regulate elevator or basket tosses being performed on any surface other than grass, mats, or rubberized tracks.31

After evaluating the data on both critical heights and the use of various types of flooring, it might be concluded that the AACCA rules need to be reevaluated. The safest surfaces to perform the maneuvers listed above would be on landing mats placed on top of traditional foam flooring or on spring flooring.30 In addition, coaches need to be educated on the effects of critical heights and the potential of injury. Coaches could use this information to choose appropriate surfaces for their cheerleaders to perform or practice on, and in turn, they could possibly reduce the amount of traumatic brain injuries that occur while participating in this emerging competitive sport. Although the literature provided useful insight on the potential of how to reduce the amount of traumatic brain injuries, it did not elucidate the type of surfaces that would have similar injury reducing potential for other types of injuries.30

**Warming Up and Injury Prevention**

Warming up can be separated into two categories, which include general warm-up and specific warm-up. General warm-up is defined as any sort of exercise that is not similar neuromuscularly to the specific sporting event that the athlete is preparing to take part in. They include various types of stretching and calisthenics in this category. The following are examples of general warm up.

- Jogging or jogging in place
- Jumping jacks
- Side left/side right
• Grapevine and carioca and variations

• Kick backs

• Head rolls

Specific warm-up includes activities that the athlete will be performing and involves large rhythmic movements that are repeated in order to prepare for a particular skill such as those listed below.\(^ {32,33}\)

• 5 T jumps
  5 tuck jumps
  5 left hurdlers
  5 right hurdlers
  *Take three 8-counts to breathe*
  5 pikes
  5 toe touches

• 10 toe touches
  5 toe touches
  5 pikes
  5 right hurdlers
  5 left hurdlers
  *Take three 8-counts to breathe*
  5 tuck jumps
  5 T jumps
  5 sets of double jumps

A proper warm-up will result in the following:
Increased blood flow to the active muscles
Increase rate of force development
Increased reaction time
Increased strength and power
Lower muscular resistance
Increased temperature and therefore, increased oxygen delivery
Increased metabolic reactions which allows for a better utilization of fuel
Quicker muscle contraction and relaxation

Stretching and Injury Prevention

Flexibility is a key aspect to cheerleader safety, injury prevention, and improved performance. Before stretching, it is recommended that athletes perform some form of aerobic activity for warm up, such as running, for a minimum of five minutes in order to increase blood flow to the muscles. Performing a stretching program while muscles are cold could cause tears in the muscles. It takes more force and a greater stretch in muscle length to injure the muscle during activity than if it has not been warmed up. Some of the major muscle groups that should be stretched prior to practice or competition include the groin, quadriceps, hamstrings, and lower back musculature. Other areas that should be stretched are shoulders, triceps, calves, hips/glutes, and hip flexors. Some of the added benefits of stretching specific to cheerleading, in addition to increased flexibility and injury prevention, include promotion of proper leg lift, increase of leg height during kicks and jumps, and decrease of muscle energy expenditure.

There are many different types of stretching including static and dynamic stretching. Static stretching includes a slow movement of the relaxed muscle into the elongated position up to a thirty second hold at the end of the available range of motion. Dynamic
stretching is defined as increasing flexibility by performing active movements that are sport specific. Although speed of movement is incorporated, the athlete should avoid bouncing but utilize movement patterns that are applicable to the particular sport.

There are two very distinct goals for stretching, one being to improve flexibility and the other to prevent injury. There has been an on-going debate on whether static or dynamic stretching is better for flexibility and/or power. Equally controversial is when is the best time to stretch, prior to or after practices and competitions. The evidence supports that the best time to perform static stretching is during practices but not during pre-competition because of lower scores from judges, decreased power, and longer ground contact times. This leads to the conclusion that to improve flexibility, static stretching should be performed after practices and competitions. Static stretching has been shown to lead to decreased muscular performance when dynamic constant external resistance is applied. Other negative effects of static stretching include decreased height when doing a vertical jump and decreased performance during explosive movements (i.e. power). Conversely, evidence indicates that dynamic stretching leads to an increase in performance and power when dynamic constant external resistance is applied doing a leg press. Although, the research certainly implies that dynamic stretching for injury prevention would be preferable to static stretching for athletes that need high power output during competition, ultimately, more research needs to be conducted on this topic to specifically target competitive cheerleaders. Dynamic stretching should be incorporated in the warm up at the beginning of every practice and competition. Static stretching should be performed at the end of every practice and competition. Sample exercises are listed in Appendix D.
**Balance and Injury Prevention**

Functional balance training on an unstable surface for ten minutes a day, four days per week, throughout the duration of the athletic season (i.e. competition mesocycle) can potentially increase postural stability and core strength.\(^{37}\) Functional balance training has been used for years to train postural muscles to activate, provide stability, reduce risk of injury, and rehabilitate injured athletes.\(^{38}\) Balance training engages the core musculature and requires postural control.\(^ {37}\) The goal of training these postural muscles in a functional manner is to increase the rate of firing of the core muscles in order to get the muscles to contract prior to the functional movement. By doing this, the body is more likely to be in a biomechanically correct position and decrease risk of injury in the athlete. Unstable surfaces such as foam, wobble boards, balance discs, and Swiss balls can be used for this type of training.\(^{37}\) Since balance plays an integral part in injury prevention for athletes participating in other sports, it would reason that balance should be part of an injury prevention program for cheerleaders.\(^ {38}\) The ankle strengthening program listed in Table 4 targets ankle musculature through functional balance training beginning with single-leg balance training on a stable surface and progressing to unstable surfaces. As previously noted, stage I of the program should begin during the off-season. The athlete should progress the balance exercises as dictated in Table 4 and continue the progression through the in-season (competition) mesocycle.

**Pre-participation Screening**

Most of the participation screening focuses on issues that would lead to sudden cardiac death (SCD). In addition to SCD, there has been some research conducted on pre-screening for the female triad in female competitive athletes. The triad has been defined as female athletes that have eating disorders, amenorrhea, and who are subject to osteoporosis.\(^ {39}\) These conditions
have also been associated with decreased levels of estrogen, bone loss, stress fractures, and infertility.

Pre-participation history taking was examined to evaluate their effectiveness. Results suggested that 67% of high school administrators did not ask questions about menstrual dysfunction and only 22% of those surveyed asked questions about eating disorders.

An additional method of pre-screening prior to competition that has not been used frequently but that is now currently required is the Functional Movement Screen (FMS). During the FMS analysis, seven movement patterns, which focus on mobility and stability are assessed. The seven items (Table 13) are the deep squat, hurdle step, in-line lunge, shoulder mobility movement, active straight leg raise, trunk stability push up, and a rotary stability movement. Even though an athlete may appear to be at a high level performance-wise, they may be using compensatory movement strategies and have muscular imbalances or weakness that are putting them at higher risk for injury. For example, an athlete may be able to perform a high number of sit ups during testing, but they might be compensating for weak abdominal musculature with too much cervical flexion and use of the upper body. The FMS is designed to analyze an individual’s areas of weakness, mobility impairments, instability, or muscular imbalance, which might predispose the athlete to higher potential for injury. Once the athlete’s potential areas of weakness have been identified, specific exercises to strengthen those areas can be incorporated into their periodized RT program. The use of additional specific training activities, identified by the FMS, might reduce injury and also aid in improvement of overall performance measures. Professional athletes, such as the subject in the case study, may benefit from a FMS assessment and use of additional training activities. The professional athlete in the case study reported that for her particular organization there was no required patient
history taken, screening, exercise program or team program prescribed in order to prepare physically for the demanding 82 plus game cheerleading season. It is likely that a FMS would have been able to identify specific areas of weakness that each individual athlete could then target before the competitive season to decrease potential injury and increase performance measures. The descriptions of how the FMS is scored are found in Appendix C.

Table 13. Components of Functional Movement Screen<sup>40, 41</sup>

<table>
<thead>
<tr>
<th>Movement Pattern</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep Squat (Figure 13)</td>
<td>Assesses bilateral, symmetrical, functional mobility of the hips, knees, and ankles</td>
</tr>
<tr>
<td>Hurdle Step (Figure 14)</td>
<td>Assesses stride mechanics, coordination, and stability of the hips and trunk in addition to single-leg stance and stability</td>
</tr>
<tr>
<td>In-Line Lunge (Figure 15)</td>
<td>Assesses hip and ankle mobility and stability, quadriceps flexibility, and knee stability</td>
</tr>
<tr>
<td>Shoulder Mobility Screen (Figure 16)</td>
<td>Assesses bilateral shoulder ROM, IR/Add, ER/Abd, scapular mobility, and thoracic spine extension</td>
</tr>
<tr>
<td>Active Straight Leg Raise (Figure 17)</td>
<td>Assesses active hamstring and gastrocnemius/soleus flexibility, while maintaining a stable pelvis and straight opposite lower extremity</td>
</tr>
<tr>
<td>Trunk Stability Push-Up (Figure 18)</td>
<td>Assesses trunk stability while symmetrical upper extremity movement is performed</td>
</tr>
<tr>
<td>Rotary Stability Screen (Figure 19)</td>
<td>Assesses multi-plane trunk stability during combined upper and lower extremity movement</td>
</tr>
</tbody>
</table>

*Injury Prevention and Increasing Performance through Resistance Training and Conditioning*

Cheerleading is an activity that takes a great deal of power, strength, and force generating capacity in order to perform the required complex tasks.<sup>42</sup> Participating in an exercise program that adequately prepares the athletes physically for competition is one of the key aspects of injury prevention. When developing an RT program for cheerleaders, it is relevant to consider that the mass of the cheerleader must not become too large because it could hinder performance capability. A balance between size, flexibility, strength and force-generating capacity must be
maintained. In addition, there are three main themes that should be considered when developing RT programs for cheerleaders to achieve the greatest amount of power:

- RT at less than 50% of 1RM
- RT between 50 to 70% of 1RM
- RT that utilizes a periodization program that uses a mixture of both

Periodization

Included in an injury prevention program should also be a well-planned periodized resistance training (RT) program. Sample periodization programs for the partner, base, and spotter at the high school level can be found in Appendix D. These programs utilize several essential training principles such as volume, intensity, specificity, etc.

A periodized RT program utilizes a method of training that manipulates training variables to optimize results and assists an athlete in reaching peak performance. This type of training is necessary since an athlete can only maintain peak physical status for performance for two to three weeks. It is imperative that the periodized program accurately prescribes a training program that is able to have the athlete in their peak physical condition that coincides with the peak of the competitive season.

Two of the most common types of periodization programs that have been successful in helping athletes to achieve gains in strength, overall fitness and performance are called linear and nonlinear. Nonlinear periodization programs typically have more frequent alterations in training volume and intensity. Although some researchers favor nonlinear periodization programs, attributing this type of program to higher gains in strength, other researchers have concluded that both types of programs elicit similar effects in motor performance, power, body composition, and body mass. Two important variables for both types that are manipulated throughout the annualized RT program are training intensity and volume.
The typical model of periodization contains a macrocycle, which can also be termed an annualized plan lasting one year. That macrocycle is usually separated into four larger training phases or mesocycles. These mesocycles can be divided using a 3:1 loading paradigm. For example, the load will continue to be increased for the first three weeks or microcycles. Then, there will be one week (i.e. microcycle) of unloading, which allows the athlete’s body to adapt and also reduce the potential for fatigue. This type of loading and unloading is called undulating.

Mesocycles, as indicated previously, are usually separated into microcycles, which typically last from one to five weeks. The classical periodization program should be designed so that the highest intensity training occurs during the “competitive season.” In this paradigm, athletes will decrease their training volume, increase intensity, and maximize their strength and power for the competitive season. An example of this paradigm for high school competitive cheerleading in Florida, a winter sport, would be to design their RT and conditioning program so that their peak performance occurs during their winter competition period. Some of the main goals of periodization are to prevent overtraining/under performance, add variety to workouts, and assist athletes to achieve peak performance. The four mesocycles most frequently used are listed and described below (Table 14).
Table 14. Mesocycles and Type of Activity Performed\textsuperscript{32, 34}

<table>
<thead>
<tr>
<th>Phase</th>
<th>Type of Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation (Off-season)</td>
<td>Athletes, during this phase, perform high to moderate volume, low to moderate intensity workouts. Resistance training exercises are performed using an intensity between 50-80% 1RM. Athletes should also perform aerobic and anaerobic exercise in addition to working on flexibility.</td>
</tr>
<tr>
<td>First transition (Preseason)</td>
<td>During this time athletes progress to moderate to high intensity and moderate to low volumes of exercise. RT would be performed at 80-90% 1RM. Athletes continue with flexibility exercises and should perform interval aerobic training in this phase.</td>
</tr>
<tr>
<td>Competition (In-season)</td>
<td>Athletes perform very high intensity, very low volume training. RT should be at 90-95% 1RM. Training is also to be performed in short bursts and be very sport specific.</td>
</tr>
<tr>
<td>Second Transition (Postseason)</td>
<td>This is historically the active recovery (AR) portion of the macrocycle. During this time period, all activities should be low intensity and include recreational activities, participation in other sports, and a lot of variability.</td>
</tr>
</tbody>
</table>

The periodized RT program should only be devised after an analysis of the sport is performed. Analysis should include evaluation of the requirements and the characteristics of the sport in addition to a physical assessment of the athlete. The following are the three subsets of analysis.

- Movement analysis
  - Movement patterns
  - Muscular involvement

- Physiological analysis
  - Strength, power, hypertrophy, and muscular endurance priorities

- Injury analysis
  - Common joint and muscle injury sites and causative factors

When assessing the athlete, the following considerations should be incorporated.

- Training and injury status (pre-participation physical)
- Testing
Muscular strength testing
- 1 RM bench press
- 1 RM back squat
- Maximum muscular power
- 1RM power clean
- Vertical jump test
- Muscular endurance testing
- Push-up test
- Sit-up test
- Aerobic capacity
- 1.5 mile run
- Flexibility
- Sit and reach test
- Body composition
- Skinfold measurements
- Functional Movement Screen (FMS)

- Evaluating results
- Determine primary goal of training

In addition to following the parameters for exercise prescription for periodization, athletes should also incorporate exercises that can further develop areas of weakness, mobility deficits, instability, or muscular imbalance that have been identified in the Functional Movement Screen (FMS). Another consideration for exercises to be performed in the periodized plan should be related to the most common injuries that occur for cheerleaders. These exercises
might include balance exercises for ankle strengthening and stability as well as strengthening and stabilization exercises for the neck and core. Examples of these exercises were listed in previous sections and their placement within the periodized RT program can be found in Appendix D.

In-season and off-season training

The RT program should be sport specific and individualized for each cheerleader. For example, a lower level high school cheerleader may not have the same physical demands as an elite level collegiate team member performing complex stunts or the professional cheerleader identified in the case study (Appendix B). Along the same lines, a male cheerleader who is primarily performing lifts should not train the same way as a female who is the one being lifted. A greater mass would not necessarily be required for the base; however this athlete would need a greater amount of strength and power generation for performance as opposed to a partner. Therefore, specificity is another key element to the RT and injury prevention program. The principle of specificity refers to an adaptation either metabolically or with respect to physiologic functions based on the type of exercise performed or the amount of overload. As previously mentioned, competitive cheerleading is a sport that also requires power. This type of training will be emphasized during the late preseason and in-season (first transition and competition mesocycles) phases as the athletes approach their season’s peak.

Anaerobic or power performance has been shown to be hindered by taking part in aerobic endurance training concurrently. Although some researchers believe that speed endurance training should be utilized to enhance an athlete’s recovery rate and improve their capability of performing even more high-intensity bouts during a competition. However, other researchers have found that general aerobic endurance training reduces the ability to increase muscle cross
sectional area precluding strength gains and therefore decreasing anaerobic force generating capacity. Concurrent aerobic endurance and resistance training has also been known to interfere with an athlete’s ability to develop explosive strength.

Aerobic endurance (i.e. cardiovascular fitness/CRF) is one of the first elements targeted during an off-season conditioning program, which is the preparation mesocycle. Improvement in oxidative metabolism, is one of the main goals of aerobic endurance training, which would be useful to endurance athletes as well as power athletes; however, with the possibility of aerobic endurance training of being counterproductive for power athletes, it can be inferred that this type of training would not be beneficial for cheerleaders after the initial off-season phase (preparation mesocycle). Two methods that have been found to be helpful to athletes to make improvements in cardiovascular fitness are using either continuous endurance exercise (CEE) or sprint interval training (SIT). Activities that are performed in a non-stop aerobic manner for a given period of time would be defined as CEE; whereas, exercises that utilize recurring repetitions of short high intensity aerobic activities along with recovery periods would be identified as SIT. Both forms of training have been shown to be an effective means to increase aerobic endurance (i.e. CRF) and also decreases body fat. During the preparation mesocycle, CEE could be prescribed, but since cheerleaders do not have to perform for more than two minutes and thirty seconds at a time during competition, the athletes would incorporate SIT during the subsequent mesocycles beginning with the first transition.

In addition to maintaining CRF, an appropriate training program for cheerleaders will maximize strength, and increase rate of force development and output. When a program is developed in this manner, it will build on the foundation established in an earlier phase for each subsequent phase. For example, first the athlete will train for gains in cross-sectional area
(hypertrophy), then for basic strength, and finally for power.\textsuperscript{43} This corresponds to the suggested progressions of the National Strength and Conditioning Association, which describes a mesocycle in terms of increasing intensities in conjunction with decreasing volumes until the athlete reaches their season’s peak.\textsuperscript{53} The sample periodization programs in Appendix D are based upon the sequencing as suggested by the NSCA.

Training for Power

When training specifically for power development, there are largely three components that are imperative: recruitment of fast-twitch motor units, motor unit firing frequency, and synchronization of the motor units.\textsuperscript{58} Explosive training, a type of training that involves performing exercises at a load less than 60 to 80\% of the athlete’s 1RM. Performing this type of exercise has resulted in increased jump heights and rate of force development. The best time to perform this type of training would be during the preparation mesocycle (off-season) and early in the first transition (preseason) mesocycle.

Heavy resistance training, which is defined as performing training with loads greater than 80\% of the athlete’s 1RM, has been shown to increase strength and promote maximal recruitment of motor units. This type of training should begin late in the first transition mesocycle (preseason) and continues through the in-season (competition) phase.

Both of these types of exercise would be beneficial for developing increased power production since they assist in producing gains in the generation of force and maximal strength, respectively. In addition, both should be included in a periodization program; however, there must be care given when they are prescribed because heavy resistance training has also been
shown to cause increased muscular hypertrophy (i.e. mass), which can also decrease muscular performance for cheerleaders.\textsuperscript{58}

However, lifting lighter loads ballistically does not lead to maximum gains in overall strength to the same degree as performing RT with heavier loads. Evidence suggests that athletes that have high levels of strength, defined by researchers as being able to squat a minimum of two times their body weight, have also been shown to achieve higher gains in muscular power and athletic performance.\textsuperscript{43}

Other Periodization Considerations

During the initial phase (off-season) of a periodized program, athletes should perform a greater variety of exercises in order to target as many muscle groups as possible. However, during this same time they should perform fewer sets of each exercise (i.e. one to three). As they approach competition (in-season), the number of exercises should be reduced to a few specific exercises with a greater amount of sets.\textsuperscript{59}

For athletes who may not have participated in a periodized RT before and are not as experienced, it is suggested that a periodization program that has very little variation (i.e. number of exercises) be used.\textsuperscript{50} However, the progression of this type of program will still have a very sequential, logical transition from basic hypertrophy and endurance exercises to strength and to power exercises. As previously mentioned, the taper or unloading portion of periodization is very important for the athlete to make physiological adaptations and recover before transitioning to subsequent stages.\textsuperscript{50} The athletes should also have a tapering period prior to competition. During this phase, RT is reduced by means of decreasing volume, intensity, and/or training
frequency in the days preceding a competition. The periodization programs in Appendix D reflect the suggestions for tapering and unloading.

One of most common mistakes made during exercise prescription and periodization is progressing the athlete’s training program too quickly or improperly. In order to allow an adequate amount of time for physiological adaptations and recovery, exercise programs should be progressed gradually and increase no more than a five to ten percent of one training component, intensity or duration/sets. A good time frame for progression would be every two weeks.60 Another method of increasing training load is called the 2-for-2 rule.34 By these guidelines, the athlete increases their training load during their next training session after they are able to perform two or more repetitions more than their target number in the final set during two previous consecutive training sessions on a specific exercise. Other guidelines for load increases are listed in Table 15.34 By utilizing these guidelines to develop appropriate progressions specific for an individual athlete, a solid foundation of physical fitness or readiness for competition can be developed and promote optimal performance with minimal injuries.

Table 15. Estimated Load Increases Based on Type of Athlete and Section of the Body Trained

<table>
<thead>
<tr>
<th>Type of Athlete</th>
<th>Section of the Body</th>
<th>Estimated Load Increase (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Smaller, weaker, less trained” (S/W/LT)</td>
<td>Upper body</td>
<td>2.5-5</td>
</tr>
<tr>
<td>S/W/LT</td>
<td>Lower body</td>
<td>5-10</td>
</tr>
<tr>
<td>“Larger, stronger, more trained” (L/S/MT)</td>
<td>Upper body</td>
<td>5-10+</td>
</tr>
<tr>
<td>L/S/MT</td>
<td>Lower body</td>
<td>10-15+</td>
</tr>
</tbody>
</table>

Utilizing appropriate training frequency is also an important variable to consider when developing an appropriate RT program for any athlete. Although factors such as training status of athletes will frequently alter the requirements for training frequency, RT performed three
times a week is usually appropriate and allows a sufficient amount of recovery for athletes in order to prevent overtraining and make positive adaptations. Generally, athletes need to have one to three days of recovery in between RT sessions that target the same muscle groups. For periodization, the following frequency guidelines have been suggested for athletes.

- Off-season (Preparation phase): 4-6 sessions per week
- Preseason (First Transition): 3-4 sessions per week
- In-season (Competition phase): 1-3 sessions per week
- Postseason (Second Transition): 0-3 sessions per week

Exercises should be arranged in a manner that allows an athlete to utilize the appropriate energy system(s) to complete the set with proper form. This suggests that athletes must have an adequate rest period between sets. Rest periods between sets are also dependent upon what the athlete is trying to achieve. If an athlete is doing RT to increase strength, then rest periods should be several minutes in duration. However, if the athlete is trying to achieve muscular endurance, the rest period should be reduced to less than a minute. For aerobic endurance training, the rest period should be reduced to less than thirty seconds in duration. Similar considerations for rest periods based off of RT goals are:

- When training for strength, rest periods should be 2-5 minutes in duration
- When training for power, rest periods should be 2-5 minutes in duration
- When training for hypertrophy, rest periods should be 30 seconds to 1.5 minutes in duration
- When training for muscular endurance, rest periods should be no more than 30 seconds

Exercise order is another variable that can be manipulated within a periodization program to promote the efficacy of the training program goal. The National Strength and Conditioning Association supports the following concerning the training principle of exercise order:

- When targeting all major muscle groups in a single session:
  - Large muscle groups should be trained before smaller muscle groups.
  - Multiple-joint exercises should be performed prior to single-joint exercises.
When training for power, total body exercises should be performed before more basic exercises are performed with the idea that more complex exercises should be performed first.

- This is the order that should be prescribed because power exercises are the most complex and require higher skill levels and concentration. If these exercises are not performed first and the athlete is fatigued, it puts them at greater risk for injury due to poor technique.

- Alternation between upper and lower body exercises is also a good way to order a training session.
  - By alternating upper and lower body exercises, the athlete is able to shorten the duration of their training session because they require shorter rest periods between exercises. Even with these shortened rest periods, each area of the body is allowed adequate recovery time.
  - Similarly, alternating pushing and pulling exercises maintains the same principle. Alternating with this agonist and antagonist concept, allows one area of the body to rest, while the other contracts, therefore minimizing fatigue. This is called a superset.

- Certain exercises that target different muscle groups can be performed between sets of other exercises in order to promote efficiency during a training session.

- Higher intensity exercises should be performed prior to lower intensity exercises.\(^\text{53,62}\)

Exercise selection should be specific for each athlete and also based on a movement analysis for the sport.\(^\text{34}\) Exercises should be selected based upon the movement patterns associated with the sport in order to train the most commonly used muscle groups. For example, cheerleaders jump, throw, and sprint depending on whether they are performing stunts, jumps, or tumbling. Appropriate exercises for those movement patterns are:

- Jumping: power clean, push jerk, back squat
- Running/sprinting: lunge, step-up, heel raises
- Throwing/Lifting: pullover, overhead triceps extension, incline bench press, shoulder press
- Preparing for lifts: front squat

The following are examples of exercises that could be used in the periodization program based on the goals of the specific mesocycle and/or individual training session.\(^\text{50}\)

Hypertrophy:

- Squats
- Single-leg deadlift
- Bench press
- Lat pull-down
- Shoulder press

Strength:

- Parallel back squats
- Single-leg deadlift
- Bench press
- Weighted chins
  - Note: Most of these exercises are the same as the hypertrophy exercises. Other parameters would be altered in order to change the outcome of training. For instance, the number of sets would increase, reps would decrease, load would increase, and rest period might be longer.

Power

- Snatch
- Jump squats
- Bench throws
- Power clean
- Push jerk
- Parallel back squat

Note: Once again, to continue to manipulate variables to obtain the desired outcome, the sets would increase, reps would decrease, load would be variable, and rest periods would be longer. The training program considerations listed above have all been applied and can be seen in the periodization programs in Appendix D.

**Readiness to return to competition**

Depending on the injury of the athlete, there are various protocols that are followed with respect to how much time an athlete needs to recover or what they should physically be able to do before returning to competition (i.e. protocol for ACL repair). However, there are three different aspects to reintegration to competition that should be considered. The first subset of factors to be considered when determining whether or not an athlete is ready to return to competition are athletes’ pain, lack of strength, or range of motion. Various clinicians have reported that active range of motion should be between 70 to 100% of full range, the motion should be pain free, and the joint or area should be stable, have no swelling, and have no
palpable tenderness present prior to return to play. The general consensus is that return to play should occur when the injured limb as reached an equivalent status as the contralateral limb. The second element to consider examines the affected area or risk of re-injury. Cheerleading is a contact sport, but not a collision sport. The clinician should contemplate which position (i.e. spotter, base or partner) the injured cheerleader fills because it might affect when the athlete returns to competition. Additional considerations include limb dominance, competitive level, and the athlete’s ability to protect the joint or injured structure through bracing or padding should also be weighed. Finally in the return to play equation, the clinician needs to consider timing, pressure from both the athlete and external sources, masking of the injury with cortisone or other medications, conflict of interest, and fear of litigation. Beyond the physiological challenges, a psychological assessment can be utilized to assist in determining the athlete’s readiness to return to practice and competition. The Injury-Psychological Readiness to Return to Sport Scale (I-PRRS) and Total Mood Disturbance Scores have been used to determine an athlete’s readiness to return to competition. A final consideration that needs to be taken into account is that if an athlete attempts to return to competition before they are ready psychologically, it poses additional risks of not only re-injury but also incurring a new injury.

**Summary**

In conclusion, cheerleading is a highly competitive sport that continues to attract more and more participation every year. The sport continues to increase in complexity and physical demand, raising the potential for injury with its evolution. This paper was intended to assist coaches, cheerleaders, athletic trainers, strength and conditioning specialists, physical therapists, and other healthcare professionals in their understanding of the sport and the athletes that
participate in it. Aspects of cheerleading such as biomechanics, methods of injury prevention, and rehabilitation methods after injury are all necessary components to ensuring the safety of these competitive athletes. Items addressed in injury prevention include flexibility, resistance training, balance, pre-participation screening, appropriate surfaces for performance, and readiness to return to competition after rehabilitation. The most imperative aspect of providing cheerleaders with the greatest protection from injury is making sure that they are in appropriate physical condition for sport performance. The best way to ensure this is by having each athlete perform a properly designed periodized resistance training program. This program should incorporate exercises to assist the athlete to achieve peak physical condition as well as specific exercises for injury prevention. Prior to making recommendations for injury prevention, a thorough investigation of biomechanics based on position and stunt was conducted as well as incorporation of statistical evidence on incidence and prevalence of various injuries related to cheerleading. This investigation was performed with the ultimate goal of gathering the most up to date information for the cheerleading and healthcare communities to utilize to promote safe competition and reduce the incidence of injuries of competitive cheerleaders.
References:


23. Childs JD, Cleland JA, Elliot JM, Teyhen DS, Wainner RS, Whitman JM, Torburn L.


## Biomechanics of Cradle Stunt

### THE CRADLE: BIOMECHANICS

<table>
<thead>
<tr>
<th>BASE</th>
<th>THE CRADLE: PRELOAD</th>
<th>ASCENDING</th>
<th>TOP OF STUNT</th>
<th>DESCENDING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LEs:</strong></td>
<td>hips flex: Quadriceps and gluteus maximus eccentrically contract ankles dorsiflex: eccentric contraction of the gastroc/soleus</td>
<td>hips extend: quadriceps concentrically (explosively) contract, gluteus maximus contracts, ankles plantar flexed, engaging gastroc/soleus</td>
<td>standing with hips and knees extended; hip, knee, and ankle musculature surrounding the joints are all engaged to support the joints and stabilize</td>
<td>hips flex eccentrically, knees flex, ankles dorsiflex; quadriceps, iliopsoas, gluteus maximus, gastroc/soleus, all engaged eccentrically during the catch</td>
</tr>
<tr>
<td><strong>UEs:</strong></td>
<td>wrist flexors contracting, elbows extended, but biceps brachii and brachioradialis active as well</td>
<td>elbows flex and then explosively extend: biceps brachii engaged first then triceps brachii shoulders flex and deltoids contract</td>
<td>triceps brachii contracts,</td>
<td>deltoids, biceps brachii, wrist flexors all engaged during the catch</td>
</tr>
<tr>
<td><strong>Trunk:</strong></td>
<td>spinal stabilizers engaged: TA, QL, rectus abdominis, internal/external obliques, erector spinae muscles active</td>
<td>Trunk: spinal stabilizers engaged;</td>
<td>abdominals and erector spinae/abdominal corset remain engaged</td>
<td>Trunk: spinal extensors are particularly active, iliocostalis, longissimus, spinalis, in addition to trunk stabilizers and abdominals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PARTNER</th>
<th>THE CRADLE: PRELOAD</th>
<th>ASCENDING</th>
<th>TOP OF STUNT</th>
<th>DESCENDING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UEs:</strong></td>
<td>wrists extended but performing active wrist flexion, elbows flexed performing extension concentrically contracting the triceps brachii; latissimus dorsi concentrically acting</td>
<td>concentric contraction of gluteus maximus and quadriceps; concentric, explosive movement of the gastroc/soleus bilaterally</td>
<td>rigidly in extension with triceps brachii contracted; wrists in neutral, fingers flexed; arms adducted</td>
<td>Hip flexors (iliopsoas) contracts, quadriceps still engaged to maintain knee extension, ankles PF (gastro/soleus contraction)</td>
</tr>
<tr>
<td><strong>LEs:</strong></td>
<td>eccentric contraction of gluteus maximus and quadriceps; eccentric contraction of the gastroc/soleus</td>
<td></td>
<td>hips and knees extended, ankles in neutral: with all musculature surrounding the joints engaged to maintain a rigid standing position</td>
<td>triceps brachii maintain contraction, middle deltoids/ supraspinatus contract abducting the arms; fingers remain flexed with wrists in neutral</td>
</tr>
<tr>
<td><strong>Trunk:</strong></td>
<td>transverse abdominis, rectus abdominis, paraspinals, and obliques engaged during the entire stunt</td>
<td>Trunk:</td>
<td>Partner pikes</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPOTTER</th>
<th>THE CRADLE: PRELOAD</th>
<th>ASCENDING</th>
<th>TOP OF STUNT</th>
<th>DESCENDING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LEs:</strong></td>
<td>eccentric contraction of the quadriceps and gluteus maximus for hip flexion;</td>
<td>Concentric contraction of the quadriceps and gluteus maximus for explosive lift;</td>
<td>in full extension, triceps isometrically contracted; shoulders fully flexed with</td>
<td>eccentric contraction of gluteus maximus and quadriceps to decelerate</td>
</tr>
<tr>
<td><strong>UEs:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trunk: spinal stabilizers engaged:</td>
<td>UE: biceps brachii concentrically contracted supporting the partner at the waist</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA, QL, rectus abdominis, internal/external obliques, erector spinae muscles active for entire stunt as well</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trunk:</th>
<th>UE: bilateral concentric contraction of the gastroc/soleus as well to plantar flex the ankles during the lift</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA, QL, rectus abdominis, internal/external obliques, erector spinae muscles active for entire stunt as well</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEs:</th>
<th>UE: deltoids, pectoralis major, biceps brachii and coracobrachialis engaged</th>
</tr>
</thead>
<tbody>
<tr>
<td>knees fully extended with isometric contraction of quadriceps/hamstrings and at the ankles: isometric contraction of the gastroc/soleus complex as well as the tibialis anterior and extensor digitorum bilaterally</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEs:</th>
<th>UE: eccentric contraction of biceps brachii and brachioradialis in addition to deltoids, pectoralis major, and coracobrachialis</th>
</tr>
</thead>
<tbody>
<tr>
<td>the partner during the catch</td>
<td></td>
</tr>
</tbody>
</table>

**Table:**

<table>
<thead>
<tr>
<th>Table Cell 1</th>
<th>Table Cell 2</th>
<th>Table Cell 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trunk:</td>
<td>UE: biceps brachii concentrated supporting the partner at the waist</td>
<td></td>
</tr>
<tr>
<td>UE: biceps brachii</td>
<td>Trunk: spinal stabilizers engaged: TA, QL, rectus abdominis, internal/external obliques, erector spinae muscles active for entire stunt as well</td>
<td></td>
</tr>
<tr>
<td>UE: bilateral concentric contraction of the gastroc/soleus as well to plantar flex the ankles during the lift</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UE: deltoids, pectoralis major, biceps brachii and coracobrachialis engaged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEs: knees fully extended with isometric contraction of quadriceps/hamstrings and at the ankles: isometric contraction of the gastroc/soleus complex as well as the tibialis anterior and extensor digitorum bilaterally</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the partner during the catch</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table Notes:**

- Trunk: spinal stabilizers engaged: TA, QL, rectus abdominis, internal/external obliques, erector spinae muscles active for entire stunt as well
- UE: biceps brachii concentrated supporting the partner at the waist
- UE: bilateral concentric contraction of the gastroc/soleus as well to plantar flex the ankles during the lift
- UE: deltoids, pectoralis major, biceps brachii and coracobrachialis engaged
- LEs: knees fully extended with isometric contraction of quadriceps/hamstrings and at the ankles: isometric contraction of the gastroc/soleus complex as well as the tibialis anterior and extensor digitorum bilaterally
- the partner during the catch
Appendix B

I. Case presentation and risk management of a professional cheerleader

II. Abstract

BACKGROUND/PURPOSE: This case study subject suffered a catastrophic injury while performing a cheerleading stunt. This resulted in a concussion, three fractured vertebrae (T11, T12, L1), damage to muscles, ligaments, and two fractured ribs. Subsequently, a surgical fusion of the vertebrae, seven days of hospitalization, and having to wear a TLSO brace for the next three months was required. The athlete also has physical restrictions for lifting prescribed by her physician until one year post-injury. There may be risk management techniques that could be used by professional cheerleaders and coaches to promote injury prevention and minimize the number of accidents during performances.

METHODS: The case subject was chosen for this study due to skill level, participation in a professional organization, injury during a stunt, and the severity of the injury. The case subject was interviewed regarding the accident that occurred during the stunt, the resulting injury, remaining impairments, current participation in cheerleading, preparation during the preseason, and any risk management activity that occurred within the professional organization after the injury. Risk management techniques and preseason preparation were analyzed, and further recommendations for risk management were developed.

RESULTS: The previous steps taken have not adequately addressed the risk of injury or prevention of future incidents. Although the surgical intervention addressed the injuries that the athlete presented with, a referral to a healthcare provider, such as a physical therapist, could
address the remaining pain, impairments, and functional limitations that were associated with the injury.

III. Body of Manuscript

A. Background and Purpose

The purpose of this case report is to describe an approach designed to reduce the risk of injuries amongst professional cheerleaders. This particular cheerleader suffered a severe injury to her spine as well as a concussion as a result of falling. Participation in athletics in general poses risk of injury simply from the physical demand that it places on an athlete’s body. But there are other possible consequences, such as financial burden. Since the case subject was an independent contractor, the organization for which she performed did not provide health insurance or rehabilitation for the athlete. The athlete also suffered a back injury, which is one of the most costly injuries. From 1997 to 2005, back pain sufferers had a 65% increase in healthcare costs. In 2005, the healthcare costs of those suffering from spine problems ranged between $5670 and $6522, which is nearly double the healthcare costs of those without spine problems, $3266-$3765. Another associated consequence of injury, includes psychological distress. In fact, levels of psychological distress that are similar to those for individuals being treated for mental health issues are reported amongst 5% to 19% of injured athletes. Once athletes have physically recovered from their injuries, if they return to competition before psychologically ready, they are at a much higher risk for re-injury, incurring a new injury, depression, fear, anxiety, and hindered ability to perform. With all of these consequences, physiological, psychological, and financial, it is absolutely imperative to utilize risk management techniques to prevent injuries and their associated downfalls.
Currently, there are rules and regulations in place for younger cheerleaders up to the collegiate level. The American Association of Cheerleading Coaches and Administrators (AACCA) and National Federation of State High School Associations (NFHS) both have developed guidelines by which cheerleaders and coaches must adhere during performances. These organizations have also created educational programs for coaches, which are intended to increase coaches knowledge of safety and promote injury prevention. These guidelines, however, do not regulate cheerleading performance on a professional level. There is a great deal of current research on injury prevention for school-aged athletes, but there is no literature that supports injury prevention techniques for professional cheerleaders. One could argue that methods of injury prevention suggestions for younger cheerleaders could carry over and be beneficial for cheerleaders at higher levels; however, for that to be true, the same general regulations for performance, techniques, spotting, etc. would have to be applied.

B. Case Description

This case study subject suffered a catastrophic injury while performing a stunt called a toss shoulder stand that was intended to develop into a 2-2-1 pyramid. This particular stunt was typically performed by the athlete three to four times per athletic event and several times during every practice. Although most lower level competitive teams utilize spotters for single-based stunts, there was no spotter used during this particular performance. The athlete fell backwards head-first towards the basketball court, landing on the back of her head. Momentum caused her lower extremities to continue moving, folding her body in half at the level of the thoracic spine. This resulted in a concussion, three fractured vertebrae (T11, T12, L1), damage to muscles, ligaments, and two fractured ribs. Subsequently, a surgical fusion of the T11, T12, and L1 vertebrae, seven days of hospitalization, and having to wear a TLSO brace for the next three
months was required. The athlete also had physical restrictions for lifting prescribed by her physician until one year post-injury. The case subject continued to complain of soreness and tightness in her back ten months after injury. It was described as worse upon getting out of bed in the morning and subsiding as the day progressed. At ten months post-injury, the athlete was still unable to participate in practices or competitions and had not been referred for physical therapy by her physician.

The case subject is a professional cheerleader; however, she and her teammates are not employees of the National Basketball Association (NBA) or of the specific team that she performed for. Although it may be different among other organizations, her particular organization recognizes the cheerleaders as subcontracted performers. Therefore, there is not a governing body that regulates what types of stunts can be performed, stunt heights, flooring used, spotting, or any other aspect that has potential risk management benefits. As a result, each athlete performs at his or her own risk and the organization has no legal ties or liability when it comes to athletes’ injuries. Although this particular cheerleader states that her teammates are all former collegiate cheerleaders that follow collegiate guidelines for stunt performance, these regulations are not enforced by a governing body and other teams may not adhere to such standards. In addition, regulations may have changed during the time that had passed from college graduation to joining the professional squad. For example, as of 2012-2013 season, the AACCA started requiring spotters for the performance of single-based stunts, such as the one performed by this particular cheerleader. Although this is only required for high school level cheerleaders, it may have prevented this event had it been a requirement for cheerleaders at all levels, including professional. The athlete also reported that each individual cheerleader was responsible for his or her own conditioning program to maintain adequate fitness levels for
performance; however, these programs were not followed as a team and did not necessarily include any specific exercises designed for injury prevention. Although all of the team members are former collegiate cheerleaders and have participated in conditioning programs in the past, it would be beneficial to reassess each athlete’s health and fitness status and consider revising individual programs. In addition to practice via repetition or always using a spotter during stunts that are performed above a certain height, there are some additional methods that can be utilized in the future to promote injury prevention. There are no current guidelines designated by the NBA or the specific organization of the case subject with regards to cheerleading performance. This lack of regulation by the team, the organization, and the NBA raises concern and legitimizes the necessity for the development of formal guidelines for performance and risk management strategies.

C. Risk Management Recommendations

The regulations for collegiate cheerleaders are appropriate when it comes to guidelines for professional cheerleaders. The 2013-2014 AACCA College Safety Rules are suggested for athletes at this level and are listed in Appendix E.\textsuperscript{31} In addition, based on the most common injuries that cheerleaders incur as well as evidence based methods of injury prevention, some additional items should be incorporated into the athletes’ training programs. These evidence-based recommendations are listed below. Additional recommendations for those regulations which the AACCA has already set are listed below the guidelines. If there are no specific guidelines in place for an item, they are identified by SAR.
Suggested Additional Recommendations (SAR):

- (SAR) Balance training should be used to prevent ankle sprains, and functional balance training on unstable surfaces can promote better biomechanics, increase postural stability, neuromuscular control, and core strength.\(^{19}\)

- (SAR) Cervical spine strengthening including neck, upper trapezius, shoulder, and middle back musculature should be incorporated. These muscles act to stabilize the cervical spine when an athlete falls or makes contact with another athlete. Stronger cervical musculature has elicited fewer neck injuries amongst other types of athletes.\(^{24}\)

- (AACCA) Cheerleading squads should be placed under the direction of a qualified and knowledgeable advisor or coach.\(^{31}\)
  - (SAR) Coaches should be educated on signs and symptoms of concussion as well as evidence-based return to play protocols for athletes.\(^{25}\)

- (SAR) Core stability exercises should be included in each athlete’s training program. By increasing neuromuscular control over the smaller more local core musculature before strengthening larger global musculature, athletes can reduce their risk of low back injuries.\(^{29}\)

- (AACCA) All cheerleading squads should adopt a comprehensive conditioning and strength building program.\(^{31}\)
  - (SAR) A well planned, periodized resistance training program should be used in order to ensure that the athletes reach peak physical condition during their performance season and to avoid overtraining and overuse injuries.\(^{32}\)

- (SAR) All athletes should participate in Functional Movement Screening (FMS) prior to beginning their pre-season conditioning program. This can highlight an athlete’s
individual areas of weakness that may predispose them to potential injuries during performance.\textsuperscript{40,41}

- (AACCA) An appropriate warm-up exercise should precede all cheerleading activities.\textsuperscript{8}
  - (SAR) All athletes should perform some form of aerobic exercise for no less than five minutes prior to stretching.\textsuperscript{32,9,34}
  - (SAR) Static stretching should be incorporated in every practice and after every performance, and dynamic stretching should be done during every practice and prior to performances.\textsuperscript{32,9,34}

- (SAR) All athletes should be assessed using the Injury-Psychological Readiness to Return to Sport Scale (I-PRRS) and Total Mood Disturbance Scores to determine the appropriate time for them to return to sport psychologically in addition to basing their return off of physical objective measurements.\textsuperscript{62}

**D. Clinical Impression**

Currently within the realm of professional cheerleading, there are no governing bodies, no official safety standards, no official requirements for coaches, and each cheerleader is an independent contractor that participates at his or her own risk, eliminating all liability for the individual athletic organization. This poses a significant risk management issue. Without adherence to safety guidelines such as use of appropriate flooring, height restrictions for stunts, use of spotters, and knowledge of the potential risks of noncompliance with these regulations, athletes can be put at risk for falls and other accidents and associated injuries, which may be potentially catastrophic. In order to minimize risk of injuries, athletes’ performances should be regulated by an official governing body and the cheerleaders and coaches should all be well-versed in these regulations. The next course of action for athletes and coaches at the professional
level should be to create safety guidelines based off of the current evidence and injury trends which could possibly be done through the AACCA, which already has created guidelines for cheerleaders at the high school and collegiate level. In order to examine the benefits of creating such guidelines or safety standards for professional cheerleaders, a similar study in injury trends, including catastrophic injuries, like the case subject endured, should be conducted for professional cheerleaders. Ultimately, the long term goal would be to decrease injuries, minimize potential risks, promote organizational participation in health insurance and workman’s compensation programs, and record a steady decline in injury rates subsequent to the addition of a governing body and adherence to safety regulations including those suggested above.

E. Actions Taken to Address the Risk

Since the case subject was a subcontracted employee of the organization that signed a waiver of liability upon hire, there were no actions taken to address the nature of the incident or the risk of future occurrences by this particular organization. The athlete was taken by ambulance to receive medical attention, but there was no formal meeting amongst any of the staff or team to assess what went wrong during the stunt or to address what steps could or should be taken in the future to prevent other incidents. The athlete was solely responsible for seeking out care, following the physicians recommendations, and transitioning herself back into competition.

The case subject’s physician did not prescribe physical therapy for the athlete. Based off of the athlete’s self-reported impairments: pain and stiffness, decreased range of motion, decreased strength, impaired ability to lift, twist, bend, push and pull (all of which are necessary
to be able to continue working as a cheerleader), physical therapy would be a viable option for assisting the athlete on the road to recovery. A physical therapist could offer patient education and strategies for injury prevention, joint protection, and biomechanics; interventions for pain reduction; exercises for strengthening weakened core musculature; stretches for tight musculature; and promote a smooth reintegration into competitive cheerleading.

F. Outcome

The injured athlete’s organization did not take any actions to address the incident or risk of future incidents. This could be in part due to the waiver of liability that is signed by each team member prior to beginning the season. Each athlete is responsible for risk management on an individual basis. Currently, research on type, frequency, and severity of cheerleading injuries is substantially limited to athletes competing at the high school and collegiate levels. Inferences have been made regarding professional cheerleaders based on data collected on cheerleaders at those levels; therefore, it is not absolutely certain that if these athletes comply with the recommendations for risk management, it will reduce the likelihood of injury. However, it has been demonstrated that the recommended activities has resulted in significant specific injury reductions amongst other athletic populations.

In the future, it would be beneficial to conduct research using professional cheerleaders as the target population. The researchers could propose regulations similar to those in Appendix B that would be appropriate for professional cheerleaders, get as many teams or organizations to comply with these regulations as possible, using the non-regulated teams as the control group, and track frequency, severity, and types of injuries. Other statistics could be gathered such as
average amount of days missed due to injury or efficacy of injury prevention techniques, such as core training for minimization of back injuries.

G. Discussion

The steps taken from the time of the subject’s injury to current date have not adequately addressed the risk of injury or prevention of future incidents. The athlete utilized the emergency team on staff for initial treatment and transport to the emergency room but received no further care in association with the organization or the NBA. The athlete also underwent surgical intervention for her injuries and has been required to follow aforementioned restrictions limiting her physical activity and preventing her from return to competition, which is ultimately return to work for a professional cheerleader. Although the surgical intervention addressed the injuries that the athlete presented with, the remaining pain, impairments, and functional limitations that were associated with the injury could have been addressed via referral to a healthcare provider, such as a physical therapist. Referral to a physical therapist is an integral component not only to the athlete’s recovery from the current injury, but also to ensure that the athlete is prepared physically and mentally for return to competition, thus lessening risk for reinjury. Since the professional team that the athlete performed for had no ties to the organization or the NBA with respect to liability, no actions were taken to assess the incident, its causes, the results, or prevention of future adverse events. Also, the team operated independently of a governing organization and therefore had no guidelines to adhere to in order to minimize risk of injury and promote safe performance. In order to address the risk of similar falls or adverse events occurring, it is necessary to conduct further research that pinpointing the most common injuries that occur at a professional level, frequency of those injuries, and determine effective methods of injury prevention based on the physical demands of athletes performing at this level.
Appendix C

Functional Movement Screen\textsuperscript{40, 41}

Figure 13. Deep squat

Figure 14. Hurdle step

Figure 15. In-line lunge
**Figure 16. Shoulder mobility screen**

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Farc are within one half length</td>
</tr>
<tr>
<td>2</td>
<td>Farc are within one and a half hand lengths</td>
</tr>
<tr>
<td>1</td>
<td>Farc are not within one and a half hand lengths</td>
</tr>
</tbody>
</table>

**Figure 17. Active straight leg raise**

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Both perform one rep. with hands aligned with shoulders</td>
</tr>
<tr>
<td>2</td>
<td>Both perform one rep. with hands aligned with rib</td>
</tr>
<tr>
<td>1</td>
<td>Both are unable to perform one rep. with hands aligned with rib</td>
</tr>
</tbody>
</table>

**Figure 18. Trunk stability push-up**

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Perform one correct diagonal repetition with hands grasped parallel to board</td>
</tr>
<tr>
<td>2</td>
<td>Cross ends to touch in line over the board</td>
</tr>
<tr>
<td>1</td>
<td>Perform diagonal repetition</td>
</tr>
</tbody>
</table>

**Figure 19. Rotary stability screen**
Appendix D

Periodization Program:
Macrocycle 1 year

<table>
<thead>
<tr>
<th>MESOCYCLE</th>
<th>OFF-SEASON/PREPARATORY PHASE</th>
<th>PRESEASON/FIRST TRANSITION PHASE</th>
<th>IN-SEASON/COMPETITION PHASE</th>
<th>POST-SEASON/SECOND TRANSITION PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DURATION</td>
<td>(20 weeks)</td>
<td>(10 weeks)</td>
<td>(12 weeks)</td>
<td>(6 weeks)</td>
</tr>
<tr>
<td>MICROCYCLES/PHASE</td>
<td>HYPERTROPHY/ENDURANCE</td>
<td>BASIC STRENGTH</td>
<td>STRENGTH/POWER</td>
<td>READING</td>
</tr>
<tr>
<td>INTENSITY</td>
<td>LOW TO MODERATE</td>
<td>HIGH</td>
<td>HIGH</td>
<td>MODERATE</td>
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<tr>
<td>VOLUME</td>
<td>HIGH TO MODERATE</td>
<td>MODERATE</td>
<td>LOW</td>
<td>LOW</td>
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<tr>
<td>5-8 SETS</td>
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<td>3-5 SETS</td>
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<tr>
<td>10-20 REPS</td>
<td>4-8 REPS</td>
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<td>1-3 REPS</td>
<td>6-8 REPS</td>
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</table>

<table>
<thead>
<tr>
<th>HYPERTROPHY/ENDURANCE</th>
<th>Week 1/2</th>
<th>Week 3/4</th>
<th>Week 5/6</th>
<th>Week 7/8</th>
<th>Week 9/10</th>
<th>Week 11/12</th>
<th>Week 13/14</th>
<th>Week 15/16</th>
<th>Week 17/18</th>
<th>Week 19/20</th>
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<tbody>
<tr>
<td>INTENSITY (% 1RM)</td>
<td>50</td>
<td>55</td>
<td>60</td>
<td>45</td>
<td>60</td>
<td>65</td>
<td>70</td>
<td>55</td>
<td>70</td>
<td>75</td>
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<td>2-5 min</td>
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<th>Week 25</th>
<th>Week 26</th>
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<th>Week 28</th>
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<th>Week 30</th>
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</thead>
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<td>80</td>
<td>80</td>
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<td>2-5 min</td>
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<td>2-5 min</td>
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<td>Step ups</td>
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<td>Front plank/side plank</td>
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Appendix E

2013-14 AACCA College Safety Rules

General Program Guidelines

1. Cheerleading squads should be placed under the direction of a qualified and knowledgeable advisor or coach.

2. All practice sessions should be supervised by the advisor/coach and held in a location suitable for the activities of cheerleaders (e.g., use of appropriate matting, away from excessive noise and distractions, etc.)

3. Prior to the performance of any skill, the immediate environment for the activity should be taken into consideration including, but not limited to proximity of non-squad personnel, performance surface, lighting and/or precipitation. Technical skills should not be performed on concrete, asphalt, wet or uneven surfaces or surfaces with obstructions.

4. Advisors/coaches should recognize the particular ability level of all participants and should limit the squad's activities accordingly. Participants should not be pressed to perform activities until they are safely prepared.

5. Skills that have not been mastered should be performed only in a supervised practice environment.

6. Thorough training in proper spotting techniques should be mandatory for all squads.

7. All cheerleaders should receive proper training before attempting any form of cheerleading gymnastics (tumbling, partner stunts, pyramids and jumps).

8. All cheerleading squads should adopt a comprehensive conditioning and strength building program.

9. An appropriate warm-up exercise should precede all cheerleading activities.

10. All programs should qualify cheerleaders according to accepted teaching progressions. Appropriate spotting should be used until all performers demonstrate mastery of the skill, and when spotting is required by specific rule.

11. In environments where there is close proximity to the athletic event and out of bounds plays pose a significant risk of injury to the participant, no technical skills should be performed while the ball is in play.

12. All partner stunts, pyramids, and tosses should be reviewed and approved by the coach prior to execution.
C. General Restrictions

1. The use of any height-increasing apparatus (e.g. mini-trampoline, etc.) other than a spring floor is prohibited for performance.

2. The top person in a partner stunt, pyramid or transition cannot be released from bases or leave the floor unassisted with the intent to land or be caught in an inverted body position.

3. An individual may not jump, flip or dive over, under, or through partner stunts, pyramids or individuals from basket tosses, similar tosses, partner stunts or other tosses from hands.

4. Drops (knee, seat, thigh, front, back and split) from a jump, stand or inverted position are prohibited unless the majority of the weight is first borne on the hands/feet which break the impact of the drop.

5. Jewelry of any kind is prohibited (e.g., navel jewelry, tongue jewelry, earrings, necklaces, etc.) Medical bracelets are allowed provided they are taped to the body.

6. Soft-soled athletic shoes must be worn while cheering or competing. Gymnastics shoes, jazz shoes and/or boots are prohibited.

D. Partner Stunts

1. Twisting dismounts with more than a 360 degree rotation require an additional spotter that assists on the cradle.

2. Released load-ins from a handstand position (stationary or through a handspring load-in) to a partner stunt require an additional spotter.

3. Stunts in which the top person is in a handstand position require an additional spotter.

4. Stunts in which the base uses only one arm for support require a spotter when:
   a. The stunt is anything other than a cupie/awesome or basic liberty. All other one-arm stunts require a spotter (e.g., heel stretch, arabesque, high torch, scorpion, bow and arrow, etc.).
   b. The load-in or dismount involves a twist. The spotter must be in place during the twist and assist on the cradle during twisting dismounts.
   c. The top person is popped from one arm to the other.

5. Single based split catches are prohibited.

6. All leg pitch, toe pitch, walk-in, sponge, and straddle catch flips are prohibited.

7. Twisting dismounts greater than two rotations are prohibited. Exception: side facing stunts - i.e. Arabesque, Scorpion, double full twisting cradles to the front are legal.
8. Front, back and side tension drops are prohibited.

9. Flips into or from partner stunts are prohibited, with the following exceptions.

   a. Rewinds into a pyramid, stunt, loading position or cradle are allowed under the following conditions:

      1) The top person is limited to one and one quarter rotations and may not twist.
      2) Bases are limited to one quarter turn under the top person.
      3) An active spotter is required throughout the skill.
      4) If the rewind is continuous to a cradle, the spotter must assist in the cradle.
      5) In a rewind to a pyramid or to another base, the original base may serve as the spotter.

   b. Flips from stunts in which the top person is in an upright position standing in the hand(s) of the base(s) are allowed under the following conditions:

      1) An additional spotter must be active throughout the following skills. Exception: An additional spotter is not required for a double base front flip to the performing surface.
      2) Front flips to the performing surface are allowed from single or double base shoulder level stunts. The top person must land on at least one foot with assistance from at least one base.
      3) Front flips to a cradle are allowed from single or double base stunts shoulder level and below.
      4) Back flips to a cradle are allowed from double base stunts shoulder level and below.
      5) The top person is limited to one and one quarter flipping rotations.
      6) Dismounts to a cradle may have up to one half twist. No other twists are allowed.

   c. Flips from stunts in which the top person is in a horizontal position not being supported at their feet are allowed under the following conditions:

      1) Front flips and back flips from shoulder level double base stunts to a stunt, loading position, cradle or the performing surface with assistance from a base.
Note that flips are not permitted from a horizontal position below shoulder level or from a single base.

2) The top person is limited to one and one quarter rotation and may not twist.

3) A spotter is not required.

E. Pyramids

1. Pyramids higher than 2½ body lengths are prohibited. Pyramid height is measured by body lengths as follows: chairs, thigh stands and shoulder straddles are 1½ body lengths; shoulder stands are 2 body lengths; extended stunts (i.e. extension, liberty, etc.) are 2½ body lengths. Exception: an extended stunt on top of a thigh stand is allowed.

2. In all pyramids, there must be at least two spotters designated for each person who is above two persons high and whose primary support does not have at least one foot on the ground. Both spotters must be in position as the top person is loading onto the pyramid. One spotter must be behind the top person and the other must be in front of the top person or at the side of the pyramid in a position to get to the top person if they were to dismount forward. Once the pyramid shows adequate stability and just prior to the dismount, this spotter can move to the back to catch the cradle. As pyramid design varies greatly, we recommend a review of any new pyramids where the spotting position may be in question.

3. In all “2-1-1 thigh stand tower” pyramids, there must be a spotter who is not in contact with the pyramid in place behind the top person. If a bracer is needed to assist the thigh stand middle layer, they do not fill this role and an additional spotter who is not in contact with the pyramid is required.

4. Cradles from pyramids over two high must use at least two catchers, one on each side of the top person.

5. All flips into or from pyramids are prohibited, with the exception of a forward flip dismount to a cradle and legal rewinds.

6. Releases to prone dismounts from pyramids are prohibited.

7. Front, back and side tension drops are prohibited.

F. Tosses

1. Basket tosses or similar tosses may only be performed from ground level, can use no more than four bases, and must be cradled by three of the original bases, one of which must catch in a scoop under the head and shoulders.
2. Basket and elevator/sponge tosses may not be directed so that the bases must move to catch the top person.

3. Basket and elevator/sponge tosses cannot exceed one flipping and two twisting rotations.

4. In flipping basket or elevator/sponge tosses (tuck, layout, or pike position) only two additional skills are allowed.

   One twisting rotation is considered to be one skill.

Examples:

**Legal (two skills) Illegal (three skills)**

- Tuck flip, X-out, Full Twist Tuck flip, X-out, Double Full Twist
- Double Full-twisting Layout Kick, Double Full-twisting Layout
- Kick, Full-twisting Layout Kick, Full-twisting Layout, Kick
- Pike, Open, Double Full Twist Pike, Split, Double Full Twist
- Arabian Front, Full Twist Full-twisting Layout, Split, Full Twist

*Note: An Arabian Front followed by a 1 ½ twist is considered to be a legal skill. A Kick Double Full Twist with no flip is legal.*

5. Basket and elevator/sponge load-ins can land in a stunt or pyramid provided that the toss does not significantly exceed the height of the intended skill. Flips into stunts or pyramids from a basket or elevator/sponge load-in are prohibited.

**G. Tumbling**

1. Tumbling skills performed over, under or through partner stunts, pyramids or individuals are prohibited.

2. Tumbling skills that exceed one flipping rotation are prohibited.

3. Tumbling skills with two or more twisting rotations are prohibited.

4. Dive rolls are prohibited.

5. Airborne drops to a prone position on the performing surface are illegal. (Examples: A back flip or a jump landing in a pushup position is illegal. A handspring to a pushup position is legal as it is not airborne prior to the prone landing.)

**H. Specific Surface Restrictions**
1. The following skills are only allowed on a mat, grass (real or artificial) or rubberized track surface.

   a. Basket tosses, elevator/sponge tosses and other similar multi-based tosses.

   b. Flipping skills into or from stunts, tosses or pyramids.

   c. Two and one half high pyramids. Mounts or dismounts to and from 2 ½ high pyramids may not flip or twist on a rubberized track surface.

2. Kick double baskets and baskets that flip AND twist are not allowed at a football game during regular play or timeouts. They may be done during a pre-game or half-time situation, but only on grass (real or artificial) or matted surface with dimensions of at least 10’ x 10’. (cont’d)

3. At indoor court-type games such as basketball, the following skills may only be performed during pre-game, halftime, or post-game (not during timeouts) where the area is free of obstructions and non-cheer personnel, and all skills are performed on a matted surface.

   a. Basket tosses, elevator/sponge tosses and other similar multi-based tosses.

   b. Partner stunts in which the base uses only one arm to support the top person. Exception: Cupies/awesomes are allowed with an additional spotter.

   c. Flips into or from partner stunts.

   d. Inversions. Exception: High school level inversions are allowed. (For example, suspended forward and backward rolls, low-level inversions, and braced flips with two bracers are allowed. For college, the two bracers and top person are not required to be double based.

   e. Twisting dismounts greater than 1 ¼ rotation. Twisting dismounts up to 1 ¼ rotation on the court require an additional spotter.

   f. Two and one half person high pyramids.

   g. Airborne twisting tumbling skills (Arabians, full twisting layouts, etc. Cartwheels, round off's and aerial cartwheels are allowed.)