Overall Conditioning and Injury Prevention
A Pilates Program Developed
for a Female Adolescent Volleyball Player

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ABSTRACT

The purpose of this paper was to design a BASI Pilates program for middle school volleyball players to improve overall conditioning, alignment, and core strength in an effort to prevent future injuries. This paper focused on a case study of a young female volleyball player who was also a former competitive gymnast. Her strong athletic background was accompanied by imbalances commonly seen in gymnasts. After completing a three month individually tailored Pilates program, results showed not only improvements in her ability to master the exercises but a decrease in knee and lower back pain. In addition, there was an increase in the players’ knowledge, awareness, and confidence in her ability to successfully apply Pilates principles.
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ANATOMICAL DESCRIPTION OF THE SHOULDER

The shoulder complex is formed by three bones; the scapula (shoulder blade), the humerus (upper arm bone), and the clavicle (collarbone). A part of the scapula, called the glenoid, makes up the socket of the shoulder. The glenoid is very shallow and flat and forms an indentation (glenoid fossa) for the humerus. The glenohumeral joint (main shoulder joint) is designed for maximum mobility and allows for a wide range of upper body movements to take place (for example reaching high to hit a volleyball), resulting in a great potential for shoulder instability. The muscles surrounding the shoulder complex and the humerus can be divided into three groups; the larger muscles of the shoulder and back, muscles for scapular stabilization, and the rotator cuff muscles. The larger muscles function to produce gross movements of the arms. Key muscles in this group include the deltoids, pectoralis major, latissimus dorsi, and teres major. The deltoid is a triangular-shaped muscle on the top of the shoulder and can be divided into three segments: the anterior, middle, and posterior fibers. The action of the deltoid on the shoulder includes; abduction, flexion, medial rotation, horizontal adduction, extension, lateral rotation, and horizontal abduction. The pectoralis major is a broad, powerful muscle located on the chest. Its action is to adduct, medially rotate, flex, horizontally adduct, and extend the shoulder. The latissimus dorsi is the broadest muscle of the back, originating at the low back, ascending up the sides of the trunk and ending in a thick bundle at the base of the armpit. The action of the latissimus dorsi includes extension, adduction, and medial rotation of the shoulder. The teres major works in a synergistic relationship with the latissimus dorsi and is located along the scapula’s lateral border. The function of the teres major is to extend, adduct, and medially rotate the shoulder.

The second group of muscles connects the scapula to the surrounding bones (head, spine,
ribcage) but does not have direct connection to the humerus. The function of this group is to stabilize or move the scapula in accordance with the needs of the arm. This group is comprised of trapezius, rhomboids, levator scapulae, pectoralis minor, and serratus anterior muscles. The trapezius muscle lies along the neck and upper back with fibers blanketing the shoulders, lateral clavicle, scapula, and spinous processes of the thoracic vertebrae. The action of the trapezius (in relation to the shoulder) includes elevation, upward rotation, adduction, stabilization, and depression of the scapula. The rhomboid muscles are located between the scapula and vertebral column and function to adduct, elevate, and downwardly rotate the scapula. The levator scapulae is located along the lateral and posterior sides of the neck and acts to elevate and downwardly rotate the scapula. The pectoralis minor muscle lies next to the rib cage deep to the pectoralis major and functions to depress, abduct, and downwardly rotate the scapula. The serratus anterior lies along the posterior and lateral rib cage and acts to abduct, upwardly rotate, and depress the scapula.

*Posterior view of shoulder and back muscles* [11]  
*Anterior view of shoulder and back muscles* [11]
Supraspinatus, infraspinatus, teres minor, and subscapularis are known as the rotator cuff muscles and together they encompass, and therefore stabilize the glenohumeral joint. The rotator cuff is essential for providing shoulder stability and facilitating subtle desired mechanics of the shoulder. It helps raise and rotate the arm. As the arm is raised, the rotator cuff also keeps the head of the humerus tightly in the glenoid cavity of the scapula. The supraspinatus assists in shoulder abduction. The infraspinatus adducts the shoulder and is a synergist with the teres minor in lateral rotation of the shoulder. The teres minor is a muscle between the infraspinatus and teres major and helps to adduct the shoulder. The subscapularis is located on the scapula’s anterior surface and rotates the shoulder medially.

Rotator Cuff Muscles.

Posterior view (and top right)  Anterior view

[11]
INTRODUCTION

Volleyball Injuries and Risk Factors

According to a 2012 survey by the National Federation of State High School Associations, volleyball is the third highest sport for female participation at the high school level behind basketball and outdoor track and field. More than 380,000 girls play high school volleyball nationwide.\[^1\] At the NCAA college level in the 2011-12 school year, over 1,000 NCAA member schools sponsored women's volleyball at the varsity level, with nearly 16,000 participants across all three divisions.\[^3\] In 2012, NCAA sanctioned college beach volleyball teams for women for the first time; 14 schools sponsored the sport, with more than 200 participants.\[^3\]

It is generally accepted that the most commonly occurring volleyball injuries are acute ankle sprains, followed by overuse conditions of the knee (patellar tendinopathy), the shoulder (multidirectional instability and impingement), and the lower back (nonspecific).\[^4\] Researchers surveyed more than 400 female high-school volleyball players at 18 schools and found that the most common injury suffered by female volleyball players was an ankle sprain, followed closely by knee sprains and upper leg strains.\[^2\] Anterior knee pain (patellar tendinopathy) is the second most common diagnosis among volleyball athletes and can be attributed to overuse conditions potentially accelerated or compounded by any biomechanical issues in the athlete. Shoulder pain and dysfunction account for 8 to 20% of all volleyball injuries.\[^2\] It has been estimated that an elite volleyball player, practicing and competing up to 20 hours per week may perform as many as 40,000 hits in one season.

The likelihood that an athlete will develop a certain type of injury is dependent on either extrinsic or intrinsic risk factors. Risks factors extrinsic to the athlete include overtraining or a
hard jumping surface and, in most cases, are modifiable. Intrinsic risk factors include weak muscles or inflexible joints, muscle imbalances, or incorrect foot, spine or pelvis alignment. A player with intrinsic risk factors potentially engages in muscular and joint movement patterns that may lead to injury.

*The Five Volleyball Actions*

To better understand the potential causes of injuries and design an effective preventive program, consideration of what muscles are used and how they are used during play is important. There are five main actions initiated by the volleyball player; passing, setting, serving, hitting, and blocking. Each of these actions consists of muscular and joint movements done with precise muscular sequencing and engagement. The correct movement in correct alignment with correct muscle recruitment dictates if the action is not only effective and efficient, but lowers the probability of injury. Recruitment of the incorrect muscles in any action (such as shoulder flexion) repeated over time may lead to more chronic injuries with long-term implications such as chronic disability and functional limitation. Incorrect recruitment may be due to a lack of flexibility, mobility or strength in any of the muscles or joints involved in playing. Whether correct or incorrect movement occurs, the result is that by the time young volleyball players are playing at the college level, they have either correctly, or incorrectly, served, passed, hit, set, and blocked the ball thousands of times.

**Passing**  The player’s feet are slightly more than hip width apart, knees are bent, body is bent forward, flexed at the hip joint, and arms are loose at the sides (biceps femoris, quadriceps, gastrocnemius). As the ball comes toward the player, hands clasp together as arms straighten and biceps and triceps engage. Scapula stabilizes and shoulder flexion occurs (deltoids, pecs, trapezius, latissimus dorsi) as the ball contacts in the middle of the forearm. Legs straighten
slightly as the ball is passed into the air.

Setting  Feet are slightly more than hip width apart, knees are bent, body is slightly bent forward, flexing at hip joint, arms are loose at the sides (biceps femoris, quads, gastrocnemius). As the ball comes toward the player, arms are raised (shoulder flexion, scapula stabilization), elbows slightly bent outward, and the hands are in a triangle above forehead (biceps brachii, deltoids). As the ball connects to the fingers, elbows bend slightly and wrists bend. Elbows, knees, and wrists straighten as the ball is released.

Serving/ Hitting  Assuming a right handed hitter, the left foot of the player is slightly in front of the right foot and feet are hip width apart, knees are bent (biceps femoris, quadriceps, rectus femoris, vastus intermedius, vastus lateralis, and vastus medialis, and gastrocnemius), arms at the sides. Right leg steps forward, then left, then feet are planted quickly, right then left in quick succession, hips and shoulders facing the setter. Arms come back straight as knees bend and player jumps into the air. Both arms come into the air overhead and the hitting arm is brought back before the hit. Shoulder flexors are contracting (external rotators, anterior deltoid, pectoralis major and the coracobrachialis) to help raise the arm. During the forward movement of a player's arm swing, the external rotators are used eccentrically to slow down the arm. As the arm swings toward the ball, the shoulder extensors engage (latissimus dorsi, the sternal head of the pectoralis major and the teres major muscles). The biceps and forearm activate to assist arm movement. The triceps give support to the elbow as the arm extends toward ball. Abdominals, internal and external obliques as well as lower back muscles such as the erector spinae and the latissimus dorsi engage as the trunk is flexed forward and rotates as the arm is pulled through. The body is in forward flexion (rectus abdominus) as the hand connects with the ball and the wrist flexes. The external oblique pulls the chest downward, which compresses the abdominals. The internal
oblique also pulls the rib cage and abdominal midline toward the hip and lower back when the side bends. Transversus abdominus muscles, the deepest of the major abdominal muscles, act to compress the ribs and provide core stability.

**Blocking**  Standing with feet more than hip width apart and knees in a slight crouch facing the net. Arms are raised (shoulder flexion, scapula stabilization) with elbows slightly bent. After the hitter begins her jump, the blocker jumps (calves, quadriceps, hamstrings, gluteus and hip flexors) and then extends her arms reaching up high and pushing the hands and shoulders across the net by flexing the rectus abdominus in order to penetrate across the top of the net to stop the ball from crossing the net.

*Prevention Strategies, BASI Pilates, and Adolescent Athletes*

Current injury prevention strategies address both extrinsic and intrinsic risk factors.\(^5\) Ankle injury prevention strategies entail practicing proper footwork, integrating proprioceptive exercises, and use of ankle braces. Patellar tendinopathy of the knee (jumper’s knee) is prevented by taking time off from play and includes strengthening and conditioning the muscles of the hip, thigh, and buttocks to help absorb the shock to the knees on each jump. Shoulder injury prevention programs include the correction of any underlying shoulder problems such as imbalance, instability, or inflexibility. Prevention of lower back problems includes teaching the athlete correct posture and alignment.

No matter what the action is during volleyball, the core muscles are involved during the intricate muscular sequencing and engagement that is required for precise movements. Strengthening the deep core muscles keeps everything together and aligned and helps prevent injury and improves balance and endurance. These muscles are critical for the efficient transfer of energy during explosive movements in general; the amount of power a hitter can generate is
directly related to the strength of their mid section. Research has demonstrated that a stable, well-conditioned core plays a critical role in coordinating the body’s movements and in minimizing the athlete’s risk of both upper and lower limb injuries, as well as low back pain. [4]

Body Arts Science International (BASI) is a world-renowned Pilates program with a focus on not only overall body conditioning, but deep core strength, foundation and functional movement skills, and flexibility. Research studies reported a 12 to 21 percent improvement in muscular ability level of the legs and jump components after athletes adopted a Pilates-like training as part of their conditioning program. [12] Pilates programs have been used to build strength and flexibility in hip adductors, back extensors, and hamstrings for soccer players to help prevent injury. [6] A conditioning program using Pilates has been conducted with successful results that address muscular and skeletal imbalances in young female dancers who are especially susceptible to injuries resulting from misalignment in the pelvis. [7] A recent 2015 BASI research paper describes a Pilates program designed for a 25 year old retired professional gymnast with issues (hyperlordosis) common to that of many competitive gymnasts. [16]

The adolescent population brings both interesting challenges and opportunities to the world of injury prevention. Puberty is characterized by rapid, uneven skeletal and muscular growth spurts. This uneven growth may result in increases in imbalance and alignment issues as the player grows. The young volleyball player, going through adolescence, is extremely susceptible to injuries, more so than their adult counterparts. [8] Adolescence is characterized by expansive psychosocial development and many teens (especially girls) suffer self-esteem and self-confidence issues. A successful program must focus on increasing the female athletes’ confidence through opportunities for successful movement experiences. Pilates is unique in that it focuses on foundation and functional movement skills while fostering the mind and body
connection: the athlete becomes more aware of how her body works. A series of pilot studies was undertaken between 2004-2008 through the PMA’s (Pilates Method Alliance) Pilates in the Schools (PITS) program. Elementary students engaged in Pilates exercises over a period of ten weeks for a series of 45-50 minute sessions. Measurable outcomes indicated significant improvement. [9]

Knowledge, Awareness, Self-Confidence, and Self-Efficacy Scale (KASE-P)

The success of any conditioning program or injury prevention program depends, in a large part on the athletes’ knowledge and awareness of correct body mechanics, and the athlete’s confidence in their ability to engage in correct body mechanics. This is especially true for young athletes. The more knowledge, awareness, and confidence that the athlete has in their ability to execute specific movements in order to produce certain outcomes the more likelihood the athlete will continue to engage in sports. The Knowledge, Awareness, and Self-Efficacy-Pilates Scale (KASE-P) is a paper-and-pencil instrument designed to assess subjective aspects of change following a Pilates program intervention. The scale is based on this author’s previous work using the Knowledge, Attitude, and Self-Efficacy Scale (KASE-AQ) which measured similar attributes in asthma patients’ knowledge and ability to prevent an asthma attack. [10] The KASE-P assesses player knowledge about Pilates, awareness of body position and muscular engagement, and confidence in her ability to recruit the correct muscles and stay in alignment during Pilates exercises. The KASE-P items were generated from a list of 60 items compiled by Pilates instructors and a physical therapist. This will be the first time this test has been used and will provide information about its effectiveness as an assessment tool.
CASE STUDY

Program Timeline

The KASE-P was administered prior to the start of and following the program. The client completed 23 hours of one hour BASI Pilate sessions. Sessions occurred one to two times per week over a three month period. The Pilates studio was in the instructor’s home and equipment included a Balanced Body Reformer, Cadillac and various props.

Client Assessment

M. was a middle school (12 years old) female volleyball player who attended a local private school; the author of this paper knew her in a coaching capacity. M. had no previous volleyball experience except for her current middle school team and had played flag football and basketball at a middle school level. From the ages of 6 though 11 M. had participated at a competitive gymnastics level.

Posture assessment revealed a slight anterior tilt of her pelvis with slight hyperlordosis. Her muscular movement patterns include hypermobility in her joints and a tendency toward arching her back, flaring her ribs, and adducting her scapula. During footwork there was a propensity for hyperextension of her knees beyond straight, supination in her right ankle during high plantar flexion, and a limited range of motion during dorsiflexion. She had tight and weaker mid trapezius and latissimus dorsi muscles, tight illial tibial track, quadriceps, hamstrings, and calves. There was a strength imbalance between her quadriceps and hamstring, abductor and adductors. M. also practiced a ‘hollowing’ of her upper body (an excessive C curve with the upper back rounded). She had poor shoulder flexibility with tight internal rotators. Her range of motion was greater to the left with both lateral flexion and rotation (as a gymnast her preparations for movements were to left foot, less rotation to right side). M’s primary complaints were that her
lower back hurt sometimes and her knees hurt a lot of the time. There had been no diagnosis of lower back pain but her knee pain was diagnosed as chronic bursitis. All of the above biomechanics, characteristics, and complaints are common with gymnasts who practice and compete at high levels.

Program Focus

The conditioning program was designed for M. in preparation for volleyball and the same time addressed imbalances and current injuries as a consequence of competitive gymnastics during her formative years. The BASI block system was used for overall conditioning, focusing on core, restoring balance and control to specific muscle groups, and strengthening and stretching her shoulder area. For example, foot work was used to help correct supination, help stretch calves, and increase the range of motion of the ankle, especially dorsiflexion. In addition, focus was placed on using hamstring and gluteal instead of quadriceps muscles, as well as awareness of not hyperextending knees upon extension. The jumpboard was incorporated as well, concentrating on correct foot articulation. Hip work was used to increase the balance between hamstring, quadriceps, and increasing adductor strength and control. Stretches focused on hamstring, IT band, pectoralis and quadriceps muscles using the roller and theraband. Another focal point was on lateral flexion and rotation to balance out this area of her body and also in preparation for the hitting action in volleyball.

The primary exercises were focused on stabilizing the shoulder girdle and stretching the shoulder. M. had strong deltoids and upper trapezius muscles, tight pectoralis major and minor, and weak mid trapezius muscles. Arm work on the Reformer included Supine (strengthen shoulder extensors, adductors, and improve shoulder mobility and scapular stabilization), Sitting (horizontal abduction, shoulder extension, flexion, and abduction, and scapula abduction), and
Kneeling (shoulder abduction, horizontal abduction). Arm work on the Cadillac included Standing (shoulder extension, horizontal abduction, external rotation, and flexion of shoulders). Other exercises included but were not limited to; Pole Series, Cadillac Shoulder Adductor, Reformer Shoulder Press, and the Magic Circle (horizontal abductors, pectoral strength, shoulder adductors). Additional arm work on the Reformer included Sitting Shoulder External Rotation, Forward Push, Sitting Rows, and Sitting Scarecrow.\textsuperscript{[12]}

**CONCLUSION**

The original purpose of this paper was to provide an overall training program for a young volleyball athlete with a focus on injury prevention, specifically the shoulder. The client chosen was already an accomplished young gymnast who had accumulated muscular imbalances prior to starting the Pilates program. The focus of the program shifted from not only on preventing any future volleyball injuries but also to addressing current muscular imbalances and alignment.

Over a three month period she completed 23 hour long Pilates session. She was able to quickly master most fundamental and many intermediate exercises on the Reformer and Cadillac and by Session 6 her knee and back pain had began to subside. Throughout the program there were noticeable improvements in her ability to activate specific muscles and execute the exercises.

Prior to her training program, M’s score on the Knowledge, Awareness, and Self-Efficacy-Pilates Scale (KASE-P) reflected a moderate degree of confidence in her ability (range 1-10; mean 6.81) to complete Pilates type movements. Following the program, her KASE-P score reflected a significant rise in her confidence level (range 9-10; mean 9.95).

The results of this case study are promising. Young athletes are capable and benefit from a BASI training program that focuses on correct balance and alignment. As Pilates instructors
and advocates, our goals are to not only keep the athlete playing injury free and at the top of her game, but to also establish a lifetime of correct functional movement habits.
BIBLIOGRAPHY


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On a scale of 0-10 rate the following statements.

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1. I understand the concepts of neutral pelvis and neutral spine. _____
2. When I am laying on my back I can put my body into neutral pelvis and neutral spine. _____
3. I can stabilize my shoulder when raising my arm. _____
4. I understand the movement required for hitting the volleyball. _____
5. I can do a Roll-Up without assistance. _____
6. I know how to stretch my hamstrings. _____
7. It is easy to jump on the jumpboard using correct foot articulation. _____
8. I can keep my shoulders stable when I bring my arm to a T. _____
9. I know how to laterally flex my trunk. _____
10. I can breathe Pilates style. _____
11. I can rotate through my thoracic spine without moving my pelvis. _____
12. I understand the concept of spinal articulation. _____
13. I know how to execute a Pelvic Curl. _____
14. I can demonstrate shoulder elevation. _____
15. I can demonstrate shoulder depression. _____
16. I can abduct and adduct my scapula. _____
17. I know how to put my body into spinal flexion. _____
18. I know how to extend my spine safely using my abdominals. _____
19. I know the importance of the transverse abdominus. _____
20. I understand the difference between plantar flexion and dorsiflexion. _____
21. I understand what happens to my alignment when my foot is supinated. _____
22. I can hold my legs in table top and maintain neutral pelvis. _____