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UNDERSTANDING AND MANAGING STRESS IN COLLEGIATE ATHLETICS

JONATHAN LYNCH, MS, CSCS,*D

INTRODUCTION

The modern National Collegiate Athletic Association (NCAA) Division I collegiate student-athlete is asked to meet a high demand of institutional requirements. Classes, academic assignments, sport practice, sport performance training, medical treatment, and tutoring can all be required daily. Stress is a powerful entity within the collegiate setting, stimulating learning, growth, and performance gains within student-athletes. Too much stress however, can lead to situations of anxiety or chronic injury. Strength and conditioning coaches responsible for program implementation in collegiate athletics should understand the rigors of life for their student-athletes, and how each individual might perceive a stressful situation, both within and apart from the sport. It is important for strength and conditioning coaches, sport coaches, athletic trainers, and administrators to recognize and address the evidence of stress within student-athletes in order to avoid chronic stress-related anxiety and injury. This article will define what stress is, explore its effects on student-athletes, and provide some tips on how to combat and manage stress.

DEFINING AND UNDERSTANDING STRESS

Stress, as defined by the Merriam-Webster Dictionary, is “a physical, chemical, or emotional factor that causes bodily or mental tension,” (11). This is a systemic nervous system response caused by the magnitude of perception in relation to a relative circumstance. The body can experience stress in positive and negative ways, affecting physical performance respectively (3). Student-athletes will experience stressors through many factors, such as physical training, academic requirements, and social influence. The perception of these stressors is the product of the student-athlete’s trait anxiety, which is defined as “a personality variable or disposition relating to the probability that one will perceive an environment as threatening,” (9). An additional influencer is their situational state anxiety, which is defined as “a subjective experience of apprehension and uncertainty accompanied by elevated autonomic and neural outflow and increased endocrine activity,” (10). The combination of these factors will determine the student-athlete’s response to the stressor. The impact of a given stressor is highly individualized and can be assumed based on the prior exposure to past similar stressors, as well as the recent quantity of perceived stress.

In today’s collegiate athletics arms race, the misconception that “more is better” is slowly being exposed. The NCAA currently mandates a contact duration of four hours per day and 20 hours per week, which coaches may spend instructing their student-athletes (in-season) (13). This bylaw exists in order to allow student-athletes time to rest, recover, do assignments, and tend to their personal lives. Although four hours per day are allowed, student-athletes may benefit from reduced mandatory session length at various times. The effects of central nervous system and muscular super-compensation are generally more beneficial when properly periodized to allow for sufficient recovery from each training stimulus. Strength and conditioning coaches must understand which circumstances are most stressful to student-athletes in order to optimize their training model.

THE EFFECTS OF STRESS

The process described by Hans Selye, known as general adaptation syndrome, describes the three step progression of how the autonomic nervous system responds and adapts to perceived stress (8). The first 6 – 48 hr make up the alarm phase, during which the sympathetic nervous system activates the secretion of stress hormones. The second phase, the resistance phase, begins 48 hr after the initial stressor, during which the parasympathetic nervous system is activated and homeostasis is recovered. Without a chronic stressor, the system has enough time to adapt and recover, resulting in an improved ability to resist the same stress. The third phase, the exhaustion phase, occurs if the stressor is continued chronically before the second phase can complete, and it can result in harmful symptoms replicating the initial alarm phase.

When examining stress within the student-athlete population, it is important to consider stressors that might be outside the scope of what is implemented through an institutional source. A study by Bartholomew et al. examined an individual's ability to adapt to strength training compared to the perception of the occurrence of negative life events (2). The findings showed that individuals who had less perceived stress in their life were able to make significantly greater strength gains compared to high-stress individuals after a 12-week training protocol (2). Rationale for this finding was that life stress may interfere with the strength adaptation process in the sympathetic adrenal-medullary, neuroendocrine, and immune systems. Research examining chronic psychological stress shows that individuals who experience low levels of chronic stress (based on an undergraduate stress questionnaire) recovered faster and stronger than their high-stress counterparts (12). If strength and conditioning coaches are able to quantify the impact of chronic and acute stress on a particular student-athlete, training impact may be more easily managed. This may result in greater performance increases and reduced risk of injury and illness.

Managing stress over the course of a competitive season is imperative to the success of a team. Martinez et al. analyzed the changes in the anabolic hormone testosterone and the catabolic hormone cortisol in basketball players over the course of a competitive season (6). Findings showed that cortisol levels dropped significantly in December and April, and total testosterone levels increased throughout the season until a maximum in March (6). This information represents a two-cycle training period, with a break in December where significant recovery is present. With application to collegiate athletes, evidence shows that academic stress can result in a significant amount of perceived stress, which is unaccounted for typically. A study by Mann et al. found that the odds of a Division I collegiate football player being on the injury report were almost twice as high during times of high academic stress compared to times of low academic stress (5). Therefore, strength and conditioning coaches should plan on reducing the overall practice volume or intensity during times of high academic stress in order to optimize their training programs and reduce the likelihood of injury.

THE NEUROLOGY OF STRESS

The human nervous system consists of two modes: sympathetic and parasympathetic. As the body undergoes stressful events (either psychological or physiological, which are both neurological) it will respond with specific and predictable neurological activation. Perceived stress can cause the sympathetic cardio-accelerator nerves to signal the release of catecholamines, increasing heart rate and blood flow throughout the body. Next, sagittal plane extensor musculature in the thoracic and lumbar regions of the back become concentrically loaded due to the increased sympathetic drive. This causes the diaphragm to become a postural stabilizer and a compensatory breathing pattern to occur (7). This muscular asymmetry alters posture, resulting in faulty gait and other suboptimal movement patterns. As sympathetic neurological activation continues to increase, movement patterns become increasingly flawed (1).

In any person, the stress pathology is generally similar due to the structure of the human body. This pathology resonates in specific and predictable muscle groups based on each individual (due to structural asymmetries within the body) (4). Predicting the occurrence of biomechanical pathologies can be done through a thorough investigation of a student-athlete's habitual movement (sport and position are good indicators). When comparing leverage of local joint structure (through moment arm analysis), and based on the general stress pathology, muscular asymmetry can be identified and corrective protocols can be implemented (4). Intentional contraction of the weaker eccentrically loaded muscles may result in the reciprocal inhibition of the stronger concentrically loaded muscles. This intervention can help to resolve muscular asymmetry, restoring a relaxed state.

Super-compensation is essentially synonymous with Selye's general adaptation syndrome. The term is used to describe the process that a student-athlete undergoes in the days after a training stimulus, when performance gains are experienced. If the stress undergone during a heavy training session elicits a high impact on the body (neurologically and physiologically), a significant amount of time to recover from that training will be needed. Easier training sessions have less impact on the body, thus recovery time is shorter. While less stressful events can be easily adapted to, recurring events of moderate impact can have an adverse effect on the body as recovery time is insufficient prior to the next stimulus. This is the result of the combination of a biomechanical pathology caused by stress, paired with a lack of appropriate variation or rest time. A comparison of the total impact versus the total recovery will dictate readiness, which can be used to manage a student-athlete's total training impact (8). Without adequate recovery, patterns become overused and chronic injury can occur.

STRESS MANAGEMENT IN COLLEGIATE ATHLETICS

Planned and proper management of stress will allow for positive, and desired training adaptations to be made on a regular basis. This should be done to ensure that stressful events occur at the appropriate time and intensity, and are paired with adequate recovery periods. Common methodologies of stress tracking include monitoring sleep, resting and active heart rate, heart rate variability, training volume load (e.g., mileage, weight lifted, etc.), calories burned, and asking subjective questionnaires. Monitoring student-athletes independently is crucial in this process, as perceived stressors are highly individualized. Additionally, student-athletes may experience vastly different levels of training impact from the same stressor.

When attempting to manage stressors within collegiate athletics, a strength and conditioning coach must understand the impact that stressors have on their student-athletes. When stressors are too impactful, or too frequent, student-athletes may need increased rest time to recover from training. This, paired with added academic stress, can compound the situation, resulting in even slower than normal recovery times. Because of the variance in trait and state anxiety that individuals may experience, it is also important that a strength and conditioning coach knows the student-athletes, and what may be happening in other aspects of their lives. Psychological stressors that a strength and conditioning coach may not know about could affect the performance of a student-athlete, or even increase the likelihood of that student-athlete being injured. Interventions to relieve stress can be made easily by reducing the intensity of a training session, or replacing high-impact training with various recovery methods such as massage, stretching, or foam rolling.

Understanding what is happening in the lives of student-athletes outside of their athletic environment will provide insight on additional stressors that may need to be accommodated for. A professional, trusting relationship between strength and conditioning coaches and student-athletes should allow the training prescription to reflect levels of perceived stress, and accommodate for optimal recovery time. By understanding stress and its positive and negative effects on the body, strength and conditioning coaches will be better able to prescribe optimal training programs, putting student-athletes at a decreased risk of stress-related injury.

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CONSIDERING THE CULTURE WITHIN THE TRAINING FACILITY

ANDY GILLHAM, PHD, CSCS, CC-AASP

Every training facility has a culture, an atmosphere, and a feeling when a person walks in. This is true because humans using the same space will develop their own set of group norms, customs, behaviors, and modes of interaction, whether someone actively directs those behaviors or not (13). Some atmospheres, or cultures, are more conducive to training than others and the leaders of the facility can directly influence that culture (13). A typical coaching staff has at least three levels between head coach, full time assistants, graduate assistants, interns, and volunteers. While these titles remain consistent across organizations, rarely do the job responsibilities.

This is one way to highlight the need for an effective culture to be developed. There are multiple leaders (i.e., coaches) and when messages sent to athletes are out of alignment or otherwise confusing, athletes may become confused and uncertain how to behave. This could be as simple as one coach focusing on technique, while another coach focuses on the load. An example of this confusion is when a coach is so focused on increasing an athlete's load that an athlete develops poor technique habits in an attempt to adhere to the coach's direction, only to have a different coach come by and tell the athlete to reduce the load until the technique is squared away. This leaves the athlete in an unenviable position of needing to lift differently based on which coach is currently coaching or observing the lift. Building a situation where all of the coaches are on the same page will put the athletes in a better position to train and thus improve. The purpose of this article is to explore what a facility-level culture may look like, identify some of the expected benefits of purposely developing that culture, and discuss some misalignment between what coaches say they want the culture to feel like and the message the athletes are likely to receive.

MACRO VIEWPOINT

The importance of having a coaching philosophy is well established in sport coaching (2,8). Coaching philosophies have been explored to the point that there is now a line of research critically examining how coaching philosophy has been used (3). Some work has been done examining how "philosophy" is used in the strength and conditioning context (5). Additionally, a roundtable discussion on coaching philosophy was recently published on top-level strength and conditioning coaches (7). High school, collegiate, and professional level strength and conditioning coaches were included in that roundtable study and four commonalities were found across the competitive levels: a) having a coaching philosophy was viewed as being important, b) a coach's philosophy must be adaptable and is expected to change over time, c) ensuring athletes and sport coaches know the strength and conditioning coach's philosophy improves their buy-in to the training program, and d) a strong need to develop your own coaching philosophy instead of copying something from somewhere else. Additionally, there is some evidence that more novice coaches are less aware of their own coaching philosophy and how that translates to the bigger picture of sport, competition, and social and cultural experiences (10). However, those connections between individual actions and the collective activities of athletes and coaches have been cited as critical to the success of building an effective program (14,17). One way to picture moving beyond an individual's coaching philosophy to a more macro viewpoint is to consider the culture within the training facility.

Strength and conditioning facilities are busy places; hundreds of athletes typically move through the facility on any given day, most days of the year. In addition, there are tours, faculty members, athletic department staff members, recruits, and the strength and conditioning staff. The schedule is always well planned out, but sport coaches change practice schedules, athletes have conflicts, and some teams train as individuals, which transforms the well-planned schedule into a series of peaks and valleys of activity. That can all blend together into what seems like an uncontrollable herd, but as long as no equipment was broken or people injured, the day can be counted as a success. However, the situation does not have to be that way. The strength and conditioning staff oversees the entire training facility, which presents the staff with an opportunity to develop and systematically institute a culture for that facility. Strength and conditioning coaches are quick to detail problems stemming from working with sport coaches (16). Yet the training facility is under the direction of the strength and conditioning staff. Stand in the training facility and look at the equipment: which piece did a sport coach purchase? Watch the athletes train: how much of that training program was written by the sport coach? In both cases the answer is usually "none." There is often no need to seek approval from sport coaches on how to run the facility.

Some strength coaches can get maniacal about what clothing is worn in the facility. A mandate that dark shorts and gray or white tops are to be worn inside the facility is not a culture. Sometimes dress codes of that nature are done in reaction to offensive clothing items, but that is not the same as building a culture. When thinking about building a culture, the first step is to identify what is most important to the strength and conditioning staff. This idea of a vision being critical to success has been repeatedly cited by sport coaches as the first step toward launching competitive success (14,17). There is no real right answer here, but the task of identifying the most important characteristics is a worthy discussion in and of itself. Strength and conditioning staffs can vary widely in composition, training, and backgrounds across the different levels of coaching staff members. How many levels of coaches are involved in the discussion to identify the most valued characteristics is likely to be a highly context-specific decision. There is some logic behind having the full-time staff settle on what characteristics will be emphasized within the facility, leaving lower-level staff members to follow the directives of the full-time staff.

When the strength and conditioning staff begins to identify the most valued characteristics, the discussion needs to be focused on recognizing how those values get expressed as behaviors. Those behaviors are what is seen, heard, and felt by others and that is how the culture gets reinforced. Having taglines or expressions plastered on the walls of a facility do not foster a culture on their own. We have all been into a facility with some sort of a cliché (i.e., train like there is no tomorrow) and found more than a few athletes not giving high effort and coaches not pointing to the expression on the wall. That is not to say all expressions posted on walls are bad, simply that to systematically develop the culture of the facility, slapping some decorative words on the wall is not going to get it done.

MICRO VIEWPOINT

RESPECT

Respect is often at the top of the list when strength and conditioning coaches discuss what they want their facility to look and sound like. For athletes, this means paying attention when the coaches speak, making and maintaining eye contact when the coaches speak, not abusing the equipment, and can even mean keeping the facility clean. Where coaches often make the mistake with respect is when they do not model those same characteristics. Yelling incessantly and demeaning the athletes is not respectful behavior. Bad mouthing the sport coaches, athletic training staff, faculty members, referees, janitors, or anyone else does not show respect. Talking down to the interns sends a horribly disrespectful message to the athletes because the interns are typically closest in age to the athletes and they may even have some classes together. The music played in the facility can also be highly disrespectful. Anytime these pieces are misaligned, the reality is that the message of respect gets muddled or lost and that makes it tough to emphasize the message of respect and have the athletes heed the message.

TECHNIQUE

Coaches often seem to focus on exercise technique when highlighting what will make their facility stand out. Noticing when coaches are focused on lifting technique is easy because they rarely stand idle with arms crossed looking pensive. Instead, the coaches are more engaged, interacting with the athletes and truly teaching lifts and providing corrective feedback. This could be specific with respect to a pronated grip for one exercise and a supinated grip for a different exercise. It could be about refining and improving activities to have less wasted movement, such as no false steps when moving over and under hurdles as part of a dynamic warm-up. Often, the increased adherence to exercise technique leads to reduced injuries. The biggest challenge with technique as part of the culture is that coaches quickly tire of correcting all the mistakes athletes make during training. It is virtually impossible to correct every error in every session and attempting to do so would be highly ineffective coaching. The challenge is to find the line between what makes coaching an overly involved tedious day of training and what will keep the athletes safe and push them to consistently improve their technique and performance. When the afternoon group of athletes comes through the facility that may be the fifth group of the day for the coach, meaning that coach has corrected the angle of back flexion on the barbell back squat 50 times already that day. However, an athlete in that fifth group of the day has not been training all day and is just as likely to need the technique coaching as an athlete in the first group of the day.

It can get tedious to pause a workout to fix a technique issue, but if that is the identified characteristic that the staff has selected, then stopping the workout to correct the flawed technique is what is necessary. Coaches need to be aware of what they say. If a coach points out an athlete's technical flaw and pushes the message that technique is important, then the coach simply must pause the workout to make progress toward correcting the technique flaw. Rarely are the most junior members of staff involved in programming, but that does not mean they cannot or should not be in charge of monitoring back flexion on the back squat, for example. At the most basic level, if the staff wants to push the message of proper technique, then that verbal message needs to be followed with specific coaching behaviors to emphasize that message.

EFFORT

Giving high effort is a necessity because no training program yields positive training adaptations without the athletes putting forth high effort. Effort is also one of the easiest characteristics to notice. There is a palpable buzz in a facility where athletes are flying around giving high effort. With most strength coaches being longtime gym rats, they know that buzz and feeling of a facility filled with high-effort athletes. Yet, finding effective ways to push the athletes to that level can be problematic.

Gone are the days when simply yelling louder and verbally demanding more was the quickest route to improving athlete effort. Effort is about buy-in and, once a coach can get that proverbial ball rolling, success breeds success. Perhaps that is why getting more effort from athletes is so frustrating to so many coaches because they know with a little more effort the athletes will see more training adaptations, which likely will yield further increases in effort. That recursive effect is supported in multiple lines of research such as: a) self-determination theory (SDT) and increased competence, b) achievement goal theory with a self- and task-focused approach, and, c) self-efficacy theory and mastery experiences (1,4,11,15). SDT stems from the three basic psychological needs (competence, autonomy, and relatedness) being met. When an athlete gets the feedback from a coach that he or she was successful in a lift that serves as a boost to competence, which feels good and thus meets one of the three psychological needs. One of the critical pieces of adopting a task-focused approach is the belief that training today leads to a higher performance tomorrow, and that is both important and worthwhile. The single strongest way to improve self-efficacy is through mastery experiences, which can be as simple as increasing the load or having a coach comment on the athlete's high effort. Getting increased effort out of the athletes is an opportunity for the strength and conditioning staff to work smarter, not harder. More attention needs to be paid to setting up the environment so that increased effort is rewarded (positive reinforcement), instead of just penalizing poor effort with some form of punishment.

TEAMWORK

Working as a team is also an idealized value for most strength coaches. Athletes typically want to work in groups, so the notion of teamwork is not a difficult one to emphasize. The benefits of both social and task cohesion are well established (12). There are also some potential downsides to overly cohesive teams (9). One of the main tenants of SDT is relatedness, and teamwork and a sense of belonging clearly fit within that framework. The challenge for strength and conditioning coaches is to maximize productivity from their teams, which requires more work. One of the most asked questions is how to form groups. There are a variety of choices: a) allow the athletes to group themselves, b) position groups, c) similar ability levels, d) similar motivational levels (i.e., high buy-in athletes together), or e) opposing motivational levels (i.e., high and low buy-in athletes mixed together). With so many varieties, there is no single best answer across all contexts. One recommendation is to be purposeful in how training groups are formed and to understand and anticipate both the positives and negatives with each grouping choice. In terms of maximizing the alignment with teamwork, the coaching staff must also act as a team. This can be difficult with the differing levels of coaching positions but, nonetheless, sending the message that the whole strength and conditioning staff values one another and demonstrates working together is the important part. Coaches can also institute some peer technique checklists, where athletes specifically assess the form (e.g., depth on a back squat) of their workout partner, or peer-rated goals to further the connections across athletes and strengthen the message of teamwork being valuable (6).

CONCLUSION

Ideally, the previous examples of characteristics or values as part of a culture have prompted the thought of what happens next. According to Prim, there are three components that must be considered when developing a culture: structure, process, and people (13). The structure is the foundation and establishing that means understanding how the strength and conditioning staff wants the facility to look, sound, and feel. The process component is to purposefully build systems, customs, and norms that are aligned with the structure and reinforce the message the coaching staff wants to send. Finally, culture comes from people and this cannot be denied. Coaches get the culture they build, not simply the culture they want.

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ERROR CORRECTION—FIVE TIPS TO HELP "FIX IT"

CHERYL COKER, PHD

Communicating intricate technical details in a way that prompts an athlete to correct errors and enhance performance is a challenge faced by even the most experienced strength and conditioning coaches. However, five evidence-based motor learning practices can bridge the gap between knowing what correction needs to be made and developing effective strategies to facilitate skill acquisition. Those strategies will be the focus of this paper and are captured by the acronym "FIX IT," which prompts strength and conditioning coaches to consider the use of (1) an external **focus** of attention, (2) **inquiry**, (3) **exploration**, (4) **intervention** through purposeful manipulation, and (5) strategies that **target** the underlying cause of the problem.

Focus of Attention
Inquiry
e**X**ploration
Intervention
Target

FIGURE 1. FIX IT—AN ACRONYM REPRESENTING FIVE EVIDENCE-BASED STRATEGIES FOR ERROR CORRECTION

FOCUS OF ATTENTION

Many strength and conditioning coaches focus their athletes' attention on what their body is doing or should be doing. This is known as internal focus. In fact, 84.6 % of track coaches were reported to give instructions that promoted an internal focus (7). However, research has shown that superior learning and performance results from instructions that focus athletes' attention on the effects of their movement (8). This type of instruction is known as external focus. To illustrate the difference, an athlete can be instructed to extend his or her hips and pull the bar upward near their body, prompting them to consciously attend to those movements (internal focus). Or, he or she can be instructed to throw the bar into the ceiling, which would instead direct the attention to the desired effects or outcome of the movements (external focus). Simply changing where an athlete's attention is directed by the words used when giving instructions or feedback can affect performance. Table 1 provides more examples of directing one's focus internally versus externally.

INQUIRY

Another strategy strength and conditioning coaches should consider when correcting movements is inquiry, or questioning. Strength and conditioning coaches often feel compelled to provide feedback immediately; after all, their job is to help athletes get better. However, giving feedback too quickly can prevent athletes from developing the ability to evaluate and correct their own performance. Research has shown that delaying feedback and replacing it with questions that prompt athletes to analyze their

TABLE 1. EXAMPLES OF DIRECTING AN ATHLETE'S FOCUS INTERNALLY VERSUS EXTERNALLY

SKILL	INTERNAL FOCUS	EXTERNAL FOCUS
Landing	Flex your ankles and knees at contact	Land as softly as you can
Standing long jump	Extend your legs as fast as you can	Jump past the cone
Overhead medicine ball throw	Forcefully extend your arms	Throw the ball through the wall
Hip raise/bridge	Raise your hips	Raise your belt buckle
Suspended plank with knee tuck	Pull your knees towards your chest	Pull the straps towards your chest
Pelvic tilt	Contract your lower abs to rotate your pelvis	Push your waistband into the floor

technique leads to superior long-term performance improvement by "encouraging active learning through problem solving, discovery, and performance awareness," (2). Take an athlete that is working on the second pull in the snatch for instance. Rather than simply telling him or her that they are throwing their hips forward and through the bar, a strength and conditioning coach might ask, "how was your bar path that time?" Follow-up questions may include: "do you think you kept the bar close to your body or did it drift away during your pull?" and "what may have caused that to happen?" This way, a strength and conditioning coach can lead the athlete to the correct response, allowing the athlete to hone his or her self-reflection skills and enhance performance.

EXPLORATION

Skill acquisition is also enhanced when athletes are engaged in movement problem-solving during practice (6). In other words, strength and conditioning coaches should provide opportunities for their athletes to explore and experiment with movement possibilities. One way of doing this is through challenges (3). For example, an athlete could be challenged to see how softly they can land on top of a plyometric box while maintaining proper form. Similarly, if jumping using a series of objects, such as a plyometric box then a hurdle, they might be challenged to land as softly as possible as they come off the box but still achieve triple extension to clear the hurdle. Skill acquisition is also enhanced when athletes are given autonomy for deciding the level of difficulty of the challenges (9). By giving athletes the opportunity to make choices, such as the height of the hurdle in the jump series, practice is individualized, higher levels of motivation are developed, and athletes are empowered to further explore movement solutions leading to greater learning gains.

INTERVENTION

Intervention involves changing practice conditions to prompt changes in performance (5). This can be accomplished by purposely manipulating task and/or practice variables to elicit certain movement behaviors (4). Small-sided games, for example, increase agility demands and provide greater practice opportunities for athletes to develop their skills (2). Body position and body control during change of direction movements can be influenced by altering cone placement in speed and agility training drills. Resisting the inward pull of a resistance band positioned below the knees can correct valgus knee movement in the squat. To reduce upper body tension during running, the strength and conditioning coach can have athletes hold a potato chip in either hand. By manipulating rules, scaling equipment, altering playing area dimensions, imposing a variety of situational factors, and changing task criteria, strength and conditioning coaches can create opportunities to discover movement solutions through exploration as well as encourage movement patterns that would otherwise be difficult to verbally communicate (3).

TARGET

Whichever strategy is employed, it must target the underlying cause of the problem or it will be of little value. For example, if an athlete is having difficulty getting to parallel or the heels are rising during the squat, the underlying problem may be poor ankle mobility. In this case, providing feedback or prescribing intervention activities that target the squat form would be ineffective. Instead, functional range of motion should be focused on first.

Because errors occur for myriad reasons and what is observed is only the output of an athlete's performance, strength and conditioning coaches should start by asking why a certain behavior was observed in order to identify the true cause (3). Often, the answer will lead to one or more additional "why did that happen" questions, as the root cause of the error often occurs early in the sequence of motion. Once the strength and conditioning coach correctly identifies the source of the error, the appropriate intervention strategy can be implemented.

SUMMARY

"FIX IT" is a memorable acronym that strength and conditioning coaches can use to guide error correction efforts. Through the provision of feedback that promotes the adoption of (1) an external **focus** of attention, (2) use of **inquiry** or questioning, (3) creation of opportunities to **explore** and discover movement solutions, (4) design of purposeful **intervention** activities by manipulating task and/or practice variables, and (5) assurance that correction strategies **target** the underlying cause of the error, strength and conditioning coaches will be better able to facilitate athletes' skill acquisition.

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HAMMER
STRENGTH
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20

RICHARD ULM, DC, CSCS

Over the previous three articles of this four-part series, many different aspects of stabilization in strength training were discussed. The first article covered proper trunk (or spinal) stabilization (25). The second article introduced the concept of functional capacity (FC) and described a compensatory stabilizing strategy in the strength training population called the extension/compression stabilizing strategy (ECSS) (26). The third article introduced exercises designed to increase an athlete's FC for proper trunk stabilization to address the athlete resorting to the ECSS (27). The final installment of this series on stabilization will focus on a common exercise utilized in strength training: the squat. To many strength and conditioning coaches and athletes, the squat is a pillar of lower body training. For those involved in functional training and who utilize functional assessment, the squat is also of central importance.

As pervasive as this movement is in strength training and rehabilitation, it is often taught in a way that perpetuates the ECSS. This article will compare different squat variations as they pertain to stabilization and discuss technique that preserves and promotes proper stabilization strategies. The purpose is to shed light on these issues in hopes of helping to better apply the concepts covered in this series of articles more effectively in training (25,26,27).

REVIEW OF TRUNK STABILIZATION

Through the work of researchers and therapists, it is known that proper stabilization of the spine results from two major mechanisms:

- Co-contraction of the torso musculature (8,10,13,14,15,21,23)
- Intra-abdominal pressure (IAP) (2,8,9,10,13,14,15,18,21,23)

Pavel Kolar, a physiotherapist from the Czech Republic and creator of Dynamic Neuromuscular Stabilization, has demonstrated that both mechanisms are driven by the thoracic diaphragm (13,14,15). Attaching to the lower four ribs and the spine at the thoraco-lumbar junction, the diaphragm is located between the thoracic and abdominal cavities (Figure 1) (24). It has a horizontally-oriented central tendon surrounded by vertically-oriented muscle fibers. The diaphragm works with the abdominal wall and pelvic floor to control and stabilize the trunk and spine (13). During a concentric contraction, the central tendon is pulled downwards, approximating it with the pelvis (24). This motion compresses the abdominal contents, pushing them into the torso musculature (abdominal wall, pelvic floor, and dorsal muscles, such as the erector spinae and quadratus lumborum), resulting in co-activation of these structures. At lower force outputs (e.g., getting up out of a chair, bending down to tie one's shoes, or raising a hand to wave to a friend), this co-activation, combined with the inherent passive stability provided by the skeletal and fascial systems, is where the vast majority of trunk stability results (13,23).

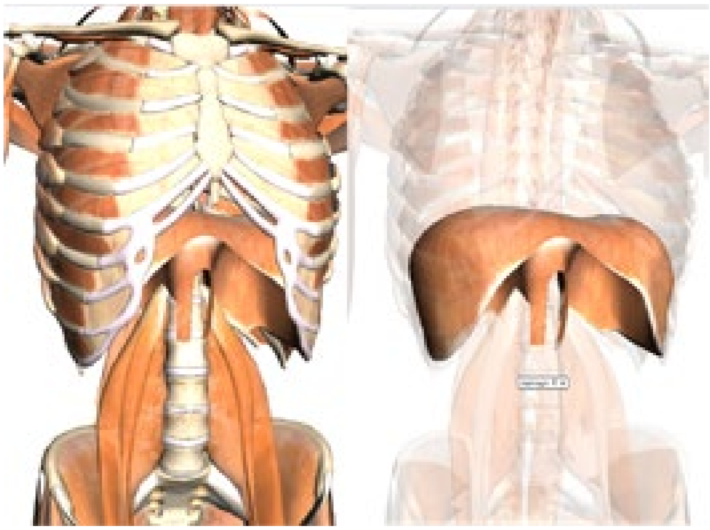

FIGURE 1. DIAPHRAGM

At higher thresholds, however, such as in the bottom of a heavy squat, an athlete will need more than just co-contraction of the torso musculature to meet the increased stabilization demands of the task—the athlete will also need IAP. Assuming the temperature and contents within a container remain constant, the only way to change the pressure within the container (such as the abdomen) is to alter the volume. This is known as the ideal gas law, the equation for which is: $PV = nRT$ (3). This law demonstrates that pressure and volume are inversely related. In regards to stabilization and IAP, this law is of central importance. By decreasing the volume of the abdominal cavity, athletes are able to increase the pressure within it. Therefore, to maximize trunk stability, which is often necessary in strength training and sports in general, the athlete needs to shrink the volume of the abdominal cavity to raise the pressure within it (8,10,13,15,18,23). This results from the diaphragm, abdominal wall, and pelvic floor working together to control the volume and, therefore, the pressure within the abdomen.

During a stabilizing event where maximal rigidity or stiffness of the trunk and spine is necessary (e.g., at impact of a kick by a mixed martial artist or during the pull of a one repetition maximum [1RM] attempt in the deadlift), the diaphragm must strongly contract to approximate its central tendon with the pelvic floor. Such an action creates a powerful outward-pushing force into the abdominal wall. In lower threshold activities, such as raising a cup of coffee to the mouth, the abdominal wall will eccentrically react to this outward-pushing force until the necessary abdominal volume (and therefore stability) has been achieved. In a maximal bracing event, however, the abdominal wall must increase its stiffness to minimize its lengthening (expansion). As the diaphragm continues to contract and approximate its central tendon with the pelvis, the abdominal wall must hold its position in a strong isometric contraction, reducing the abdominal volume to as small as possible. This reduction in volume not only generates a massive amount of IAP, but also creates a powerful co-contraction of the torso musculature, the combination of which results in the desired torso stiffness. In movements like the squat or deadlift, the athlete is attempting to make the torso as rigid as possible and the muscles are isometrically activated. Maintaining such rigidity of the torso requires utilization of both IAP and a strong co-contraction of the torso musculature.

Another principle put forth by Pavel Kolar that is very relevant to lifting technique is that if attempting to maximize these two mechanisms, an athlete needs to maintain a parallel alignment of the thoracic diaphragm and pelvic floor (Figure 2) (13). This is important for two main reasons:

1. In this position, because of the muscle fiber alignment, the thoracic diaphragm is able to maximally approximate its central tendon with the pelvis. This results in an optimal and efficient reduction of the intra-abdominal volume, enabling the athlete to generate more IAP when necessary.

2. This position is such that all of the muscles of the abdomen are able to eccentrically react to the outward-pushing force created by the descending diaphragm. This enables the athlete to co-activate all of the torso musculature instead of only a portion of them.

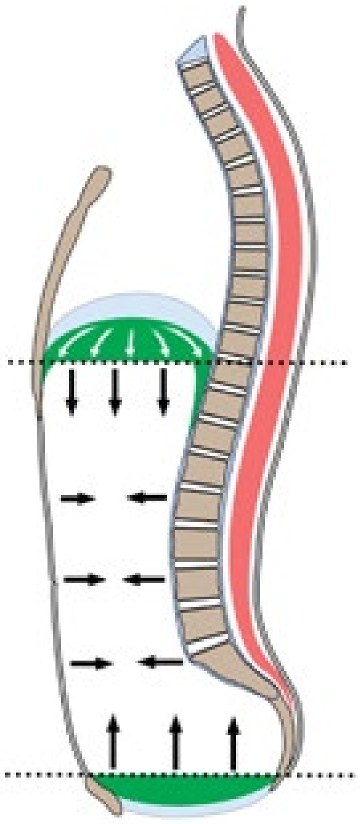

FIGURE 2. PROPER STABILIZATION – SIDE VIEW

Because of the significant stability requirements involved, proper lifting technique mandates that an athlete maintain alignment of the torso in such a position that they are able to utilize co-activation of the torso musculature and IAP. Therefore, concerted efforts must be applied to preserve a parallel relationship between the diaphragm and pelvic floor. If such a relationship is lost, then the athlete will be forced to compensate, which ultimately compromises function and performance. Unfortunately, for a variety of reasons, such a loss of positioning is common in strength training.

REVIEW OF THE ECSS

In such situations where the athlete loses this optimal (parallel) orientation of the diaphragm and pelvic floor, they are often forced into a compensatory stabilizing strategy referred to as the ECSS. Because of the postural alignment (elevated chest, hyperextended lumbar spine, and anteriorly tilted pelvis) associated with this strategy, generating maximal IAP or achieving co-activation of the torso musculature can be difficult, if not impossible (13). Instead, the athlete must generate torso stiffness via hyper-activation of the spinal extensors and hip flexors. This hyperactivity extends the lumbar spine and pulls the pelvis farther into an anterior tilt. In this position, the abdominal wall and gluteal muscles are weak and inhibited, and the diaphragm and pelvic floor are oblique to each other in the sagittal plane (Figure 3) (11,13). Here, the only means by which the athlete is able to stabilize the trunk is through extension and compression of the lumbar spine.

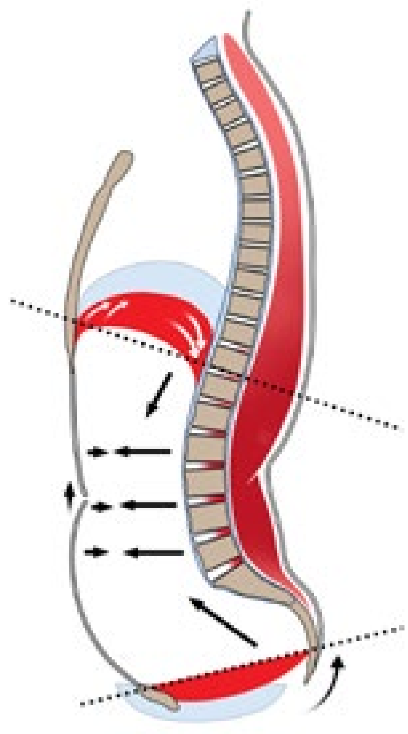

FIGURE 3. POOR STABILIZATION STRATEGY – SIDE VIEW

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What is unfortunate is that the ECSS is not only a byproduct of training, but is even internationally sought after by strength and conditioning coaches and athletes all over the world. This is perhaps most evident in the strength and conditioning industry's obsession with the posterior chain. For example, popular websites have articles specifically designed to train the "posterior chain," (Figure 4). There is no question that the posterior chain is important, even essential to function (particularly in weight training), but balanced co-activation between the posterior chain and other muscles involved in the movement is essential for optimal function (13). Over-emphasis on the posterior chain can potentially lead to injury, movement dysfunction, stubborn technical flaws, and even decreased performance.

The strength and conditioning industry's love of the posterior chain is prominently manifested in technical cuing and exercise selections. Common cues like "butt back, chest up," "find your hamstrings," and "sit back on your heels" all hyper-emphasize the posterior chain, thereby, perpetuating the ECSS. In programming, it is common to see a workout with power cleans, back squats, Romanian deadlifts (RDLs), and supermans superset with hyperextensions on the glute-ham developer for "core training." While each of these exercises has its place in strength training, this combination over-emphasizes the posterior chain and, therefore, fosters the ECSS. Athletes need to be cued properly and programs constructed in a way that trains proper stabilizing strategies instead of strengthening the athletes' compensation patterns.

FIGURE 4. POSTERIOR CHAIN

REVIEW OF PERTINENT BIOMECHANICS

In regards to trunk stability in weight training, there are many factors that make proper stabilization difficult, often even preventing it all together. This article will focus on torque. Torque is defined as a force that has the ability to cause rotational force around an axis (7). In the body, axes are found in close proximity to the joints (due to the shape of the joint surfaces, axes are not always within the joints themselves) and the torque acting on these axes is generated by the muscles. Muscles create force around an axis (joint) to prevent, control, or create motion; in each case, torque is being generated regardless of whether movement occurs or not.

In regards to biomechanics and weight training, there are two major categories of torque affecting a movement: torque generated by muscles (henceforth referred to as the effort) and torque generated by the load (henceforth referred to as the resistance). In strength training, or any movement for that matter, the effort torque (T_E) works with or against the resistance torque (T_R) to execute the movement (Figure 5).

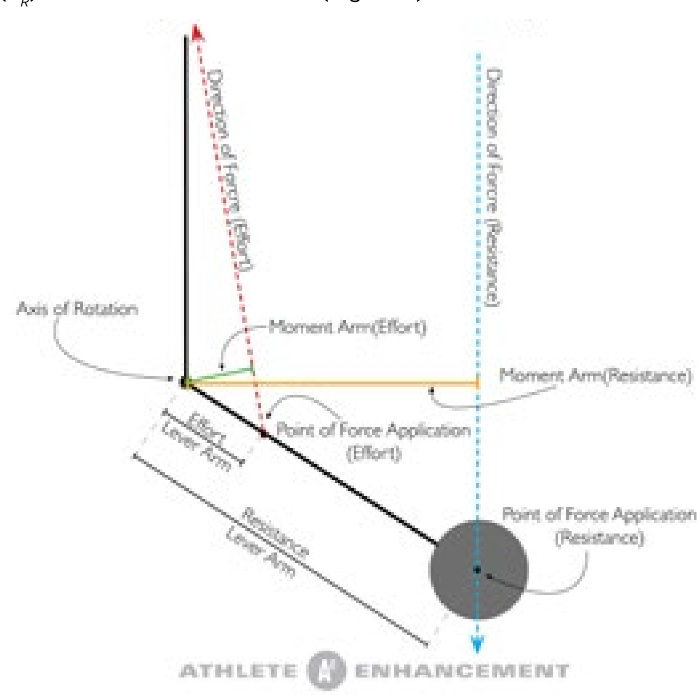

FIGURE 5. COMPONENTS OF A LEVER SYSTEM

While there are many forms of external force (e.g., friction or inertia) that may contribute to the force profile of the movement, this article will focus on one force, gravity. This is the main force discussed or quantified when lifting and is one of the main variables manipulated in training. If an athlete was asked "what is your deadlift max?," he or she would respond with a number which represents the weight on the bar, which is a quantification of the gravitational force involved in the movement.

The equation for torque is T = force x moment arm (17). The moment arm is not an actual physical structure, it is the shortest distance from the axis to the direction of force; as such, it is a straight line and is perpendicular to the direction of force (17). In the squat, unless using weight releasers, resistance bands, or chains, the load (force) does not change. However, as long as the athlete is in motion, the length of the moment arms involved are in constant flux. This means the torque output necessary to execute the movement is constantly changing. As the moment arms acting on all the joints participating in the movement (e.g., hip, knee, and ankle mortise) lengthen and shorten, the torque output necessary to overcome the load in a given position change (Figure 6). The proportionate length of the effort moment arm relative to the length of the resistance moment arm is one of the main variables dictating an athlete's biomechanical advantage (or disadvantage) over the load—a huge factor influencing proper technique. It is also one of the major factors affecting the effort or difficulty to maintain proper trunk stabilization strategies. The higher the necessary torque output, the more difficult it is to maintain proper positioning (the more effort is required), the more likely an athlete will exceed their FC for this force output, driving them to compensate with the ECSS. This is most evident at the bottom of the squat. Because of a significant increase in moment arm length, it feels much more difficult to hold proper positioning than in the top of the squat.

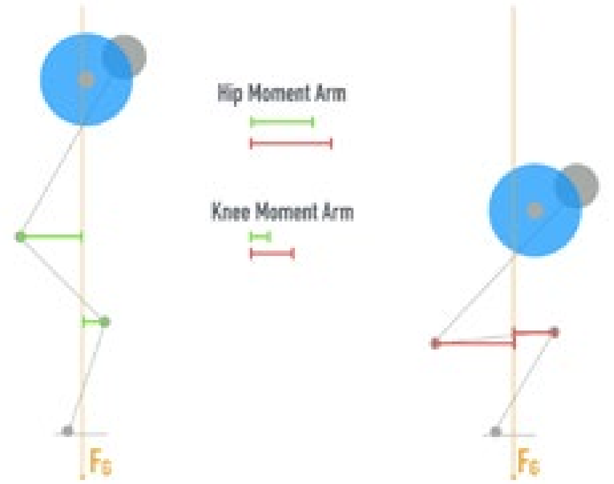

FIGURE 6. MOMENT ARM LENGTH CHANGE IN THE SQUAT

COMPARISON OF SQUAT VARIATIONS

While there are a large variety of squat variations in strength training, putting athletes in slightly different positions, this article will focus on the three main variations: high bar back squat (HBBS), low bar back squat (LBBS), and front squat (FS). In each of these movements, the athlete seeks to stiffen their torso in an attempt to make it as rigid as possible, essentially converting their 24-segment spine into one solid unit. Assuming proper technique, the spine should not move in the squat, it should only change orientation. All of the motion should occur at the hips, knees, ankles, and feet. To accomplish this with the greatest success, the athlete needs to utilize both a strong co-contraction of the torso musculature and IAP. This is particularly important at maximal and near-maximal loads, where the torque output (T_E) is very high.

Because of morphology and change in bar placement, each of these squat variations has different degrees of difficulty to maintain a proper trunk stabilization strategy. Assuming a constant load, the main factor affecting torque output is the length of the moment arm acting on the spine. As stated above, in a squat, the athlete is attempting to stiffen their torso to block any and all motion within the spine. In reality, there is an axis at each of these joints and, therefore, a moment arm lengthening and shortening as the athlete executes the movement. For clarity, this article will assume that torso stiffness is maintained so that only one moment arm acting on the torso is considered (Figure 7).

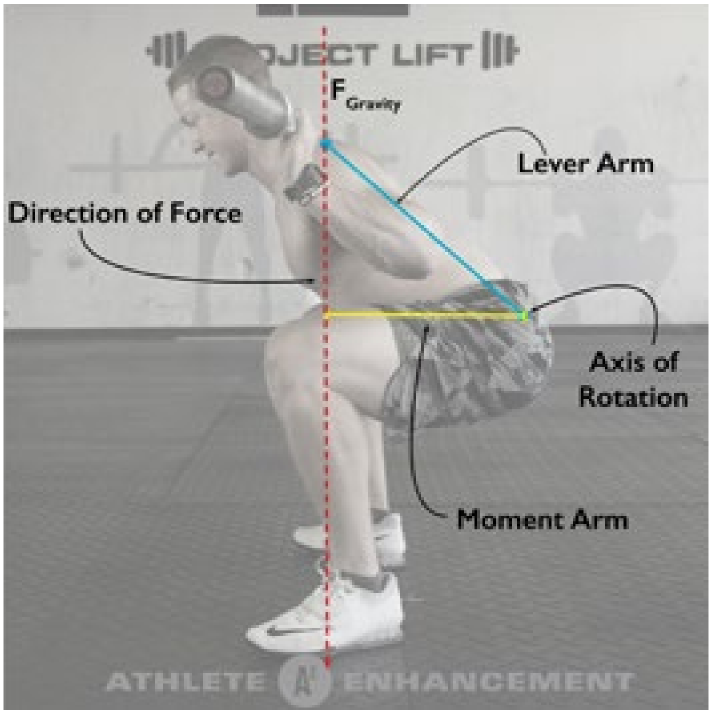

FIGURE 7. SQUAT BIOMECHANICS

STABILITY AND THE SQUAT: FRONT-LOADED VERSUS BACK-LOADED SQUATTING—PART 4

RICHARD ULM, DC, CSCS

When torso stiffness is preserved, the trunk functions like a rigid lever arm, it remains stiff and does not change length. In a lever system, the lever arm is the distance from the axis to the point where the force is applied (i.e., the point of application) (17). Unlike a moment arm, the lever arm does not change length. A good example of this is the femur (thigh bone). During a squat, the hip will flex and extend. This motion changes the position of the femur (a lever arm), which alters the length of the moment arm acting on the hip, but the length of the femur itself does not change. In an ideal situation, when torso stiffness is preserved, the length of the spine does not change in the squat.

With the torso acting as a rigid lever arm in the upright position, the moment arm is very small. However, as the athlete descends in the squat, and the torso angle becomes more horizontal, the moment arm becomes longer and the effort torque necessary to overcome the resistance significantly increases. Torso orientation, therefore, has a strong impact on the necessary torque output of the spine during a squat. This was demonstrated recently when researchers found increased activity of the trunk muscles with the trunk at 30 degrees versus the trunk at 0 degrees (6). Essentially, due to the increased torque demand, the flatter the torso angle, the more difficult it is to both maintain this orientation and to preserve the desired stiffness of the torso. This increases the likelihood that the athlete will be forced to compensate and resort to the ECSS.

Because of the difference in bar placement between these squat variations (HBBS, LBBS, and FS), the torso angle necessary to achieve a full-depth squat is different. The squat with the most vertical torso angle is the FS. Because the bar is placed in front of the spine, the torso is more vertical; therefore, the effort necessary to maintain proper posture of the trunk is less than that of the back squat variations (Figure 8).

The squat with the next most vertical torso angle is the HBBS. Unlike its low bar counterpart, the HBBS utilizes ankle mortise dorsiflexion. Because the tibia, femur, and spine are all connected by joints, there is an inverse relationship between the angle of the shin and the angle of the torso—the more horizontal the shin, the more vertical the spine and vice versa (Figure 9). Because the HBBS utilizes ankle mortise dorsiflexion, the tibia moves from a vertical position to a more horizontal one (via dorsiflexion of the ankle mortise joint and pronation of the foot) as the athlete descends, which results in a more vertical spine angle at the bottom of the squat. As such, the effort (T_E) to maintain torso positioning is less.

The squat with the flattest torso angle is the LBBS. This is because in the LBBS, athletes seek to maintain a more vertical shin angle (sometimes completely vertical) during the squat. In the LBBS, athletes often attempt to mitigate any ankle mortise dorsiflexion to 1) limit the total range of motion of the squat, resulting in less work (force x distance) and 2) maximize utilization of the hips, perhaps the most powerful of the lower extremity joints. The cost of this is a more horizontal torso angle. If the athlete kept the same bar placement as a HBBS (Figure 10), the moment arm(s) acting on the spine would be extremely long, increasing the difficulty (T_E) of maintaining proper positioning. To account for this, athletes will lower the bar placement, which shortens the moment arm(s) acting on the spine, making it easier to maintain the given torso angle. Because of the more horizontal torso angle in the LBBS, maintaining appropriate posture and a proper stabilizing strategy is extremely challenging compared to the other squat variations. This means that it is more likely that athletes will be forced to compensate into an ECSS to maintain the necessary torso rigidity in the LBBS than in the HBBS or FS.

Another factor making proper stabilization more challenging in some squat variations is bar placement. Independent of the torso angle, it is much more difficult for athletes to stabilize properly in the squat when the bar is placed on the back as opposed to front-loaded squats, such as goblet squats or FS. Perhaps because of the tactile input on the back, in both the HBBS and

FIGURE 8. COMPARISON OF TORSO ANGLE IN THE SQUAT

the LBBS, athletes typically extend their spines to handle the load. This action activates the ECSS, resulting in an inability to stabilize properly.

This is most pronounced in the LBBS. Because of the more horizontal spine angle in the LBBS, the athlete needs to lower the bar placement to shorten the moment arm(s) acting on the spine. This does improve the athlete's mechanical leverage over the resistance (load); however, because of the lower bar placement, athletes frequently arch their lower backs excessively to support the load. Because of the propensity to force the athlete into hyper-extension of the lumbar spine, back-loaded squats will more likely perpetuate the ECSS; and with it, bring the consequences in movement, technique, and performance. This is not to say that these movements should be avoided in strength training, but rather, they should be used purposefully and perhaps programmed with other ECSS-breaking exercises, such as those covered in the previous article (27).

CONSEQUENCES OF SQUATTING WITH THE ECSS

One significant cost in movement that comes with using the ECSS in the squat is a reduction in available hip flexion range of motion. Regardless of the squat being performed, hip flexion range of motion is a key factor. As the athlete descends in the squat, the hips undergo flexion. Once the athlete's hip flexion range of motion has been exhausted, they have a choice: stop at that depth or continue to squat with a compensatory movement strategy. If the athlete continues the squat, they will often do so with flexion of the lumbar spine (i.e., "butt wink") to get down to the desired depth. As has been proven many times in research by several researchers, this loaded, flexed position at the bottom of the squat is undesirable because of its link to spinal disc injury (20,21).

Unless an athlete is performing an assisted safety squat with their hands holding onto the rig and maintaining a perfectly upright torso, squatting to or below parallel without any loss in spinal position requires a minimum of 100 degrees of hip flexion range of motion. It actually takes closer to 120 degrees, if parallel is defined as the hip crease level with the top of the knee. Most people have between 110 and 120 degrees of hip flexion available (19). This means that, in most cases, athletes need virtually all of their available hip flexion range of motion to achieve a full-depth squat. Any loss in hip flexion range of motion, therefore, may result in an undesired flexed position at the bottom of the squat.

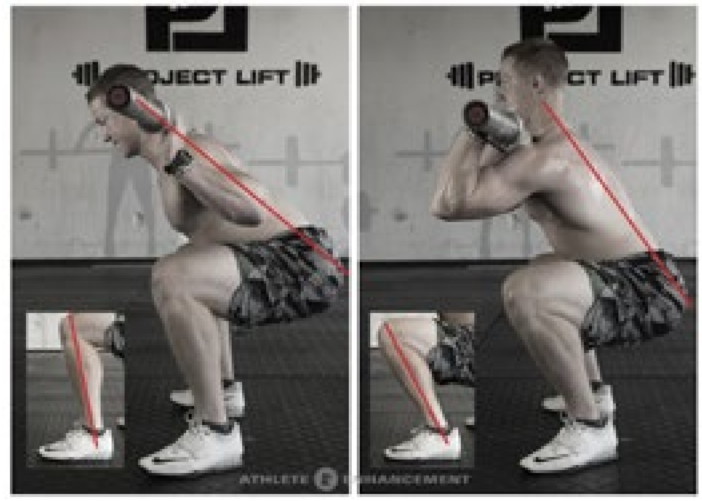

FIGURE 9. SHIN VERSUS SPINE ANGLE

FIGURE 10. BAR PLACEMENT

RICHARD ULM, DC, CSCS

One of the consequences with using an ECSS is that it affects pelvis position. People often associate an anterior pelvic tilt with lumbar extension. While this is most certainly the case, what is overlooked is the fact that when standing, as in a squat, the anterior position of the pelvis occurs as a result of closed-chain hip flexion (movement of the pelvis on the femur) (Figure 11). When an athlete stabilizes with an ECSS, the pelvis is anteriorly tilted. As discussed in previous articles, trunk stabilization precedes movement (9,10,23,25,26,27). This means that before an athlete even gets under the bar, if they are under the control of the ECSS, they have less hip flexion range of motion available to them for the squat due to the starting (postural) position of the pelvis. If an athlete happens to have typical hip flexion range of motion (e.g., 120 degrees total) and the pelvis is anteriorly tilted 30 degrees because of the ECSS, then the athlete only has 90 degrees left to use for the squat. As the athlete descends to just above parallel, they will likely lose their spinal position and compensate into spinal flexion. If, however, this athlete started with the pelvis in a neutral position, the athlete would have been able to squat below parallel without any loss in spinal position (assuming no other functional blocks, such as limited ankle mortise dorsiflexion, are present).

The requisite hip flexion range of motion necessary for proper execution of a squat is different for each variation. As discussed above, due to the changes in loading position of the bar, the HBBS, LBBS, and FS all have different torso angles. The more horizontal the torso angle in a given squat, the more hip flexion is required to execute this squat without compensatory loss in spinal position (Figure 12). Because the bar is loaded in front of the torso, the FS has the most upright torso angle and, therefore, requires the least amount of hip flexion range of motion to achieve full depth. Strength and conditioning coaches may have noticed that athletes typically are able to squat deeper in the FS than the back squat, or that the "butt wink" occurs later (deeper) in the squat motion; this is why. While the HBBS has a similar shin angle to the FS, because the bar is loaded on the back, the torso angle is flatter, which again, occurs through closed-chain hip flexion. Even though they have similar shin angles, squatting to full depth requires more hip flexion range of motion in the HBBS due to the more flattened spine angle.

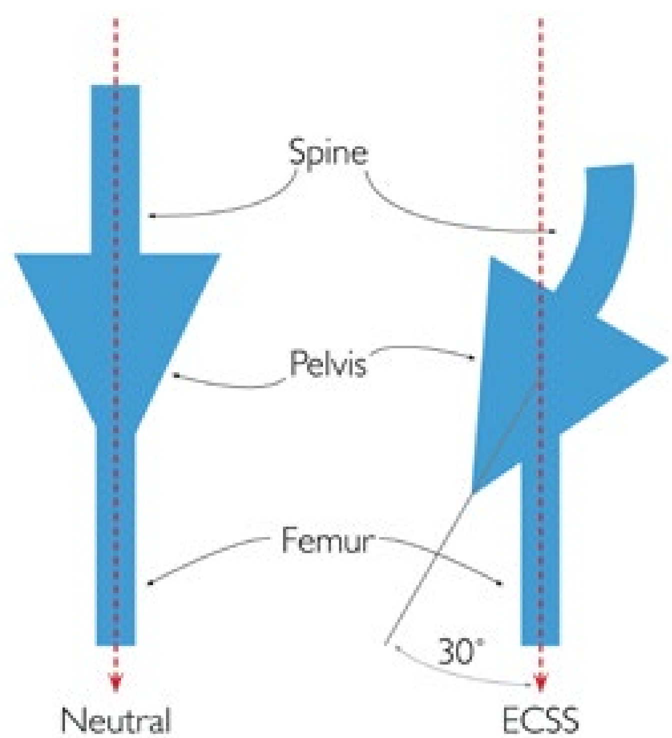

FIGURE 11. COMPARISON OF PELVIS POSITION

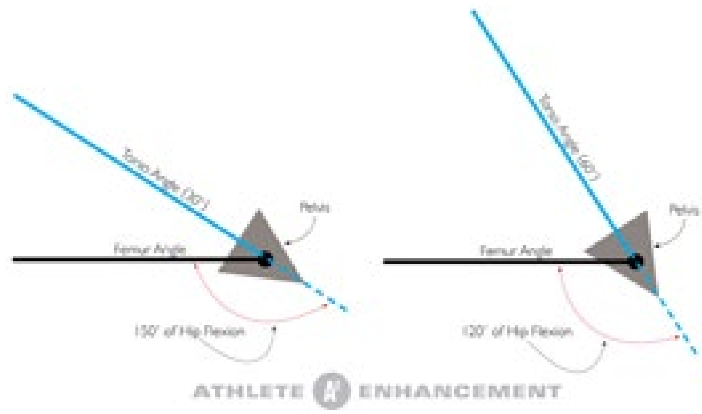

FIGURE 12. COMPARISON OF HIP FLEXION RANGE OF MOTION IN THE SQUAT (RELATIVE TO TORSO ANGLE)

The squat with the flattest spine angle and which requires the most hip flexion is the LBBS. Because the shin angle remains almost vertical, the spine angle in the LBBS is significantly more flat than the HBBS and the FS. Therefore, executing the LBBS without any loss of spinal position requires an abnormal amount of hip flexion range of motion. If the athlete lacks this prerequisite hip flexion range of motion, the athlete will be unable to achieve the desired depth without lumbar flexion.

SQUATTING TECHNIQUE

One of the main objectives in the squat is to preserve proper positioning of the torso. This enables a strong co-contraction of the torso musculature and allows maximal IAP to be generated, resulting in improved torso stiffness for increased performance and safety (13). Proper torso positioning for the squat involves the following:

- Elongated spine
- Pulled down ribcage (without loss of spinal positioning)
- Neutral pelvis (iliac crest pointing upwards towards the ribcage)
- Activated abdominal wall (not sucked in, but pushed against, as described above)

Because of the increased loads common in the squat and athletes' natural desire to push themselves, maintaining this position can be rather difficult. Additionally, executing a squat with the above described torso position requires good functional competence. If an athlete, for example, lacks sufficient hip mobility, ankle dorsiflexion range of motion, or adequate stability of the lumbar spine, then then the athlete is more likely to compensate, which often results in activation of the ECSS.

To maintain proper torso position, the athlete will need to brace for a movement. To accomplish this, the athlete must think about keeping the spine long and then pressurizing the abdomen. Pressurizing the abdomen is driven by concentric contraction of the diaphragm and it feels like one is bearing down (13). There is no drawing in of the abdomen or concentric contraction of the back muscles (spinal extensors). The athlete should think about stabilizing from the inside out. As the athlete braces, it is important that the elongated spinal position is not lost. When done properly, the athlete's ribcage will be pulled downward secondary to activation of the internal and external obliques. Often, when an athlete attempts to pull their ribs down, they will flex their spine instead of downwardly rotating the ribs on the spine (more specifically, downward rotation of the ribs at the costovertebral joints); the resulting flexed position of the spine is undesirable in a squat. Stabilizing properly in the squat is often surprisingly difficult and may require specific exercises to teach the athlete how to execute this stabilizing strategy. For examples of such exercises, please refer to the previous article (27). Once the athlete is able to stabilize the trunk properly without load, then the athlete is ready to squat.

To improve an athlete's chances of maintaining proper torso alignment, within the limits of human morphology, an athlete is attempting to maintain as vertical of a torso orientation as possible; however, an athlete does not want to do so at the expense of the torso alignment, stabilizing strategy, or knee positioning.

In regards to the knees, they should be allowed to travel forwards as long as the athlete does not lose full-foot loading or they do not travel excessively beyond the toes (5). The knees typically travel 1 – 2 in. past the end of the toes as the athlete passes through parallel, and regress back over the toes in the bottom of the squat. Moving the knees forward does help upright the torso angle (because there is an inverse relationship between shin and torso angle), but there is a point of diminishing returns. The farther the knees travel past the toes, the longer the moment arm acting on the knees (Figure 13), which increases the torque demand on the knee extensors, potentially increasing the risk of injury to this joint.

Once the bar is set and the athlete has stepped away from the rig, the athlete needs to increase their torso stiffness in preparation for the squat. To do so, the athlete will take in a breath and then, without losing the elongated spinal position, pressurize the abdomen (through a concentric contraction of the diaphragm). A good coaching cue is to "push out into your sides." "Push into your

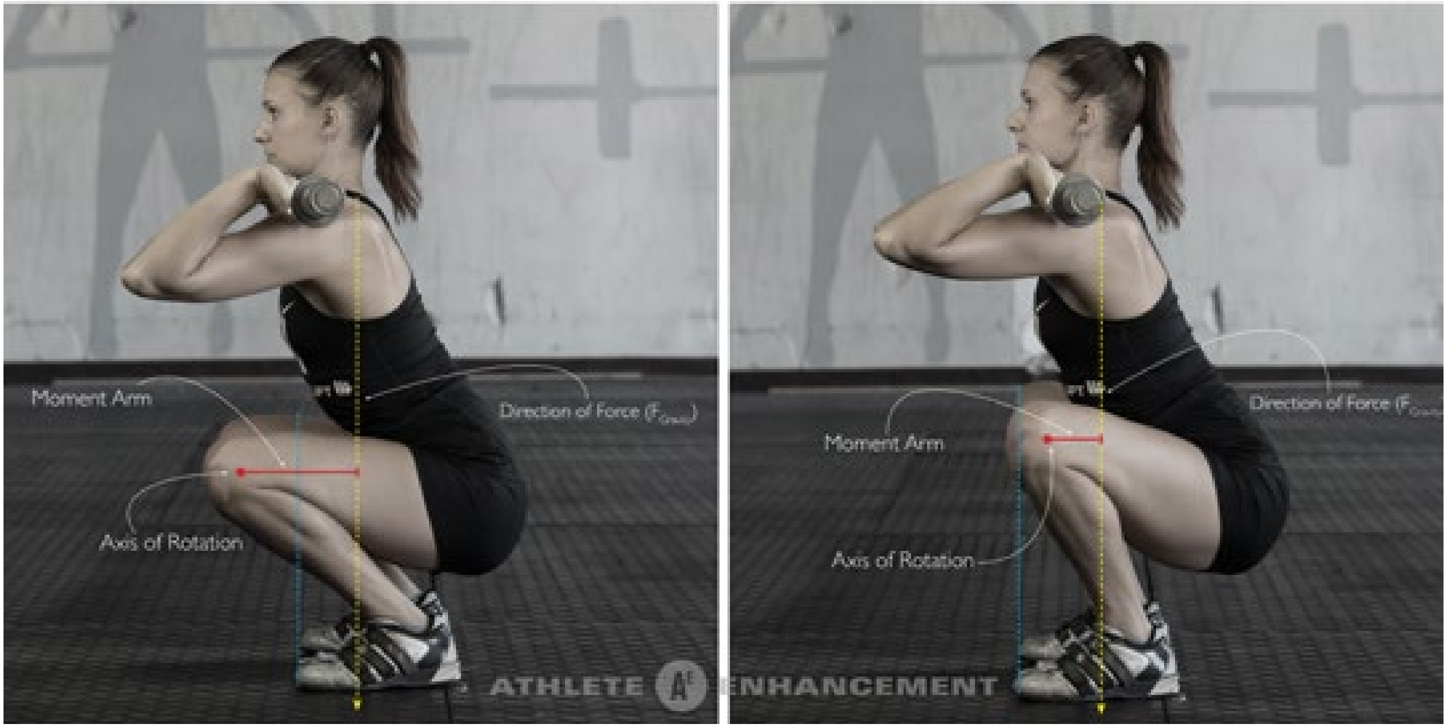

FIGURE 13. COMPARISON OF KNEE POSITION IN THE SQUAT

belly" is a commonly used cue, but may not promote a proper stabilizing strategy; it usually results in the athlete arching the lumbar spine to increase the pressure pushing forwards. If the athlete braces properly, they should feel the entire abdominal wall activate, which pulls the ribcage downward due to the activation of the internal and external obliques. Again, the action of pulling the ribcage down should not compromise the elongated spine position. Now that the torso is positioned and ready, the athlete can begin the squat.

In the squat, the bar path should be (mostly) vertical. There is, however, a setting phase where the athlete goes from standing up straight to getting into position. During this initial phase, the athlete will unlock their knees, let the hips slide back, and, in order to maintain full-foot loading, allow the torso to tilt forwards slightly. In this set position, the full foot will be loaded, the knees will be slightly bent (patella over the midfoot), and the barbell will be just in front of the toes (Figure 14). From this position, the athlete will allow the knees to move forward and the pelvis to move backward simultaneously. Once the knees have translated

FIGURE 14. SQUAT SET POSITION

forward over the toes (or perhaps 1 – 2 in. past the toes), they will stop and the pelvis will continue to move down and back until the desired squat depth has been achieved.

The athlete does not need to think about moving their torso, just maintaining its rigidity. If the athlete keeps the entire foot loaded, the spine position in the squat results from what the knees and hips do. As the athlete descends towards parallel, the torso angle will become increasingly more horizontal because the pelvis will continue to move backwards. As this happens, the moment arms acting on the spine will lengthen until they reach full length at parallel. As the moment arms lengthen, the torque the body needs to generate increases (T_{Effort}). This increased torque demand means that this position is more difficult to maintain; therefore, the athlete will have to work harder to maintain proper torso stiffness. So, as the athlete approaches parallel, they will have to focus on increasing the magnitude of the brace. What often happens is that the athlete starts in a good position, but as the athlete descends into the squat, lacking the strength to maintain proper torso position, the athlete will compensate into the ECSS. For this reason, focused effort to keep the ribs down and the abdomen braced needs to be applied, while not allowing the spine to be pulled into a flexed position.

A common coaching cue that prevents athletes from maintaining proper alignment (and perpetuates the ECSS) is "chest up." This cue is not bad in all situations, but the mentality that the chest must remain upright at all costs often causes athletes to arch their lumbar spine and elevate their ribcage, breaking the parallel relationship between the diaphragm and pelvic floor (Figure 15). Strength and conditioning coaches express this "avoid flattening of the torso angle at all costs" mentality in drills like wall-facing squats (Figure 16), which teaches the athlete to maintain an upright torso and forces them into a hyperextended position in which they have no alternative but to use the ECSS. This mentality perpetuates an environment where athletes are often afraid of a more horizontal torso angle. This position, however, is natural in a quality squat where proper torso alignment is preserved. Strength and conditioning coaches should allow the athlete to achieve a more horizontal torso angle in the squat. This will allow the athlete to preserve torso rigidity during the movement with a proper stabilizing strategy. Once the load reaches a magnitude where the athlete is unable to stabilize properly, the load can either be decreased or the strength and conditioning coach could limit the athlete's range of motion.

CONCLUSION

Squatting may be commonplace in the weight room, but proper execution of this great exercise is difficult. Strength and conditioning coaches will need to properly select exercises and cue their athletes in a way that not only allows for a proper stabilizing strategy to occur, but promotes it. Considering all the

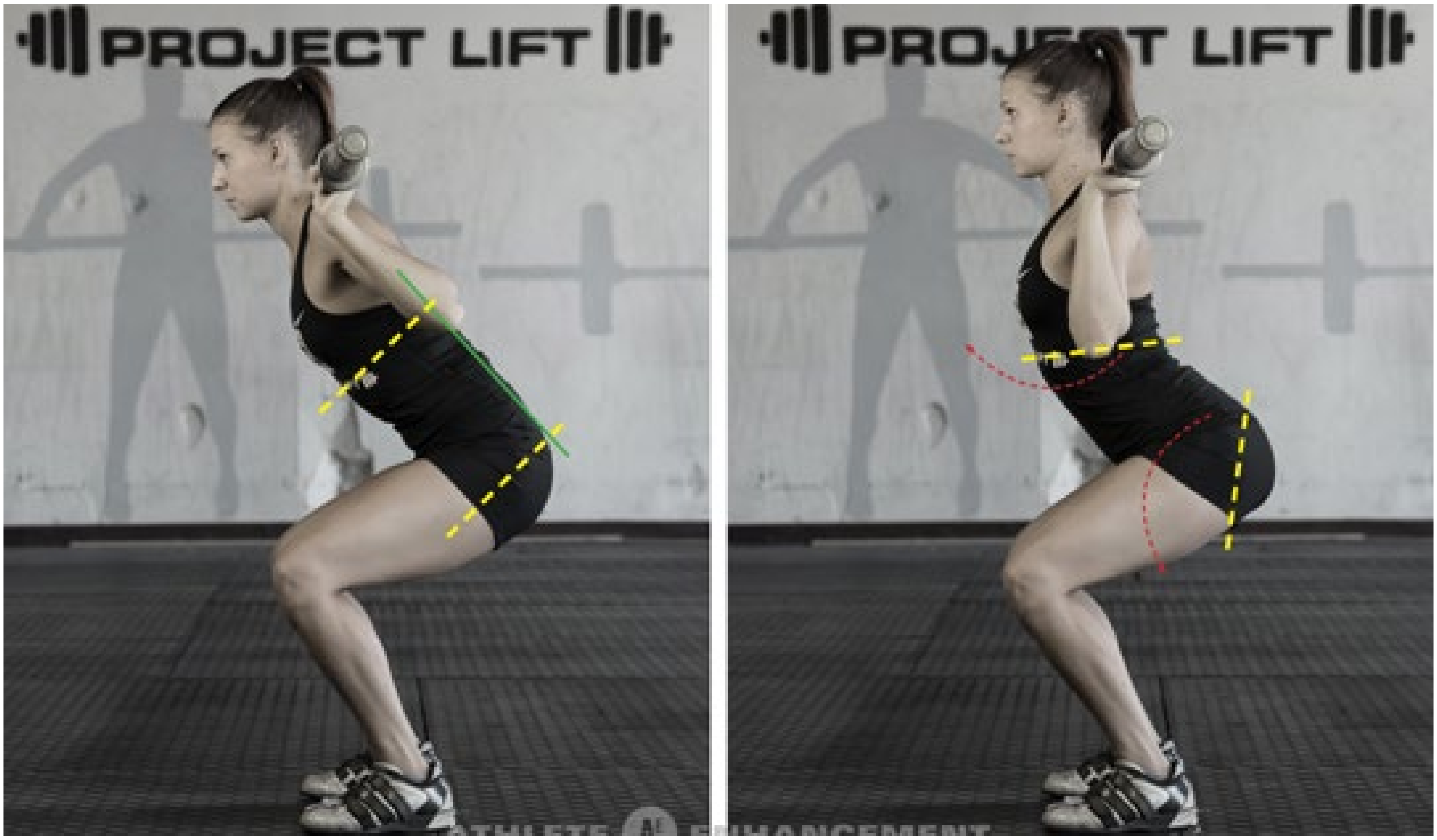

FIGURE 15. COMPARISON OF SQUATS

variables discussed above, it is the author's opinion that the squat variation that most favorably trains proper trunk stability, and which, therefore, should be favored in programming, is the FS. Both the LBBS and HBBS certainly have their place in strength training, but strength and conditioning coaches need to be aware of the high propensity of these movements to foster the ECSS and potential lower back injury due to the increased likelihood of loading the lumbar spine in flexion (20,21). Also, strength and conditioning coaches will likely need to program auxiliary exercises to improve their athlete's functional competence so that they are able to squat with the proper technique described in this article. When programming and coaching the squat, the strength and conditioning coach should be cognizant of the athlete's torso alignment and allow them to go into a more horizontal spine angle as long as they are able to maintain proper torso alignment. Remember, the ECSS is a compensation for trunk instability. As such, it comes with a cost: deceased functional competence, stubborn technical flaws, higher propensity for disc injuries, and even limiting performance. In making the transition from technique where the ECSS is utilized to the one that is described in this article, strength and conditioning coaches may find that it takes a few sessions to figure it out. However, strength and conditioning coaches and athletes will quickly discover that squatting with proper torso alignment can be extremely rewarding.

FIGURE 16. WALL-FACING SQUAT

RICHARD ULM, DC, CSCS

TABLE 1. SQUAT TECHNIQUE COMPARISON

	TRADITIONAL	NEW STYLE
Chest Position	Elevated	Down
Lumbar Spine Position	Hyper-extended	Neutral
Pelvis Position	Anteriorly tilted	Neutral
Trunk Muscles Involved	Posterior chain	All torso musculature
Stabilizing Strategy	ECSS	Ideal
IAP	Minimal	Maximal
Foot Landing	Heel	Full foot

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A PRACTICAL GUIDE TO WORKLOAD MANAGEMENT AND INJURY PREVENTION IN COLLEGE AND HIGH SCHOOL SPORTS

FRANCOIS GAZZANO, AND TIM GABBETT, PHD

INTRODUCTION

Sports injuries are a widespread problem at college and high school. In the United States alone, 1.5 million high school and college athletes are injured every year (12,18). The cause of injuries is often multifactorial; however, recent research has identified that poor workload management may be a major contributor to injuries and illnesses in sport (5,7,20,25). This article will present evidence-based workload management recommendations to reduce the risk of illness and injury in athletes, while also optimizing performance.

DEFINITIONS

Workload: Workload (often referred to as "load") is the combination of sport and non-sport stressors (25). Workload is more than competition and training loads alone, and also includes external stressors such as work, recreational activities, family, homework, etc. Workload can be divided into two sub-categories: external and internal load.

External Load: External load is the physical stresses applied to the athlete (25). It is the objectively measured physical work (e.g., number of sprints, weight lifted, total distance, etc.) performed by the athlete during competition, training, and daily life. External load is usually measured using global position system (GPS) devices, chronometers, accelerometers, dynamometers, etc.

Internal Load: Internal load is the individual physiological and psychological response to external loads, combined with daily life stressors and other environmental and biological factors (25). Measuring internal load can include objective measures, such as heart rate and blood lactate concentration, as well as subjective measurements, such as perceived effort and the overall perceived difficulty of sessions.

Internal versus External Load: While external load provides information about the work completed along with the performance capacities of the athlete, internal load is a critical factor in determining the appropriate stimulus for optimal training adaptations (25). Carefully monitoring internal load can help identify recovery needs, predict performance decrements, and anticipate health issues to adjust training and competition programs. Monitoring internal load is a cornerstone of an effective workload management program.

WORKLOAD MANAGEMENT – A KEY TOOL TO A HEALTHIER PERFORMANCE

In competitive sport, excessive fatigue plays a key role in injuries as it impairs decision-making ability, coordination, and neuromuscular control (25). The risk of injury increases when the external load exceeds the capacity of the athlete (25). For example, in professional ice-hockey, players' average playing time per game is a significant predictor of concussions (26). Fatigue has also been shown to contribute directly to anterior cruciate ligament (ACL) injury (16).

Risk of injury increases when: 1) high loads are applied to athletes who are psychologically or physically unfit to tolerate the prescribed workload, or 2) when athletes are fit and well trained, but in need of rest (7,25). In both cases, workload exceeds athlete capacity, leading to excessive fatigue and increased risk of injury. The role of workload management is to reduce the risk of injury and optimize performance. Effective workload management detects excessive fatigue, identifies its causes, and constantly adapts rest, recovery, training, and competition loads, which are based on the athletes' individual fatigue, wellness, fitness, health, and recovery levels (25).

FINDING THE "OPTIMAL" WORKLOAD

The "optimal" workload is a moving target. It differs for every athlete and changes constantly based on multiple factors, including phase of season, training status, fitness and fatigue levels, sleep quality, and non-sport stressors. Finding the optimal workload and constantly adapting training programs to the changing capacity of each athlete is complex. It is a continuous process that can require daily monitoring of internal load and at least one measure of external load (often duration or distance). Tracking and understanding how to correctly use these wellness metrics facilitates adjustment of the athlete's training program, recovery, and rest.

THE TOOLS TO EFFECTIVE WORKLOAD MANAGEMENT

An effective workload management program requires a few conditions:

- **A relation of trust and open communication between players, coaches, and training staff**: Because self-reported information is used extensively to quantify internal load and pre-training readiness, monitoring programs work best when players report their data and feedback as honestly as possible. Having the entire coaching and management team supportive of the monitoring process increases the chances of a successful outcome (21).

- **A robust workload management software**: To maximize athletes' "buy-in," the software should be able to: 1) quickly collect quality and meaningful data from the athlete with minimal effort (21); 2) monitor wellness, internal load metrics, and external load metrics; and 3) help coaches interpret the key metrics in a time-effective manner.

AN APPROPRIATE METHOD TO QUANTIFY INTERNAL LOAD

A simple, validated, and widely-used method to quantify internal load is the session rating of perceived exertion (sRPE) method (4,10). This technique combines objective and subjective measures (session duration and perceived difficulty). With the sRPE method, the athlete is asked to rate each session's overall difficulty on a 10-point scale (Table 1). The session's internal load (arbitrary units) is then calculated by multiplying the athlete's rating of the overall session difficulty by the session duration (load = sRPE x duration in minutes). The sRPE method does not require equipment and has been validated for use in a large range of sports, training, and competition activities (2,7,10).

TABLE 1. THE 10-POINT SRPE SCALE USED TO RATE THE DIFFICULTY OF SESSIONS (4)

RATING	DESCRIPTOR
0	Rest
1	Very, very easy
2	Easy
3	Moderate
4	Somewhat hard
5	Hard
6	*
7	Very hard
8	*
9	*
10	Maximal

SPORT TECHNOLOGY

Effective workload management requires monitoring the athlete's individual response to external load, the detection of excessive fatigue, and the management of external stressors with a combination of subjective and objective metrics (25). While GPS sensors, accelerometers, dynamometers, and other tracking devices are useful for assessing performance and monitoring external loads, they do not measure internal load. Heart rate monitors do monitor internal load, but they underestimate internal load during anaerobic activities, limiting their use to a small range of activities, predominantly aerobic exercise (13).

Finally, while heart rate variability is often used as an objective tool to evaluate morning fatigue, recovery, and readiness, recent research has demonstrated that subjective self-reported perceived fatigue, sleep quality, and soreness are more sensitive than heart rate-derived indices to detect daily fluctuations in training load (27). For these reasons, and even if many professional teams have access to expensive tracking technology, such equipment is not required to keep athletes performing well and without injury.

THE KEY WORKLOAD MANAGEMENT METRICS

Despite decades of scientific research and empirical experience, no single marker of athlete readiness has been shown to elevate the risk of injury or overtraining (23,25). Perhaps this is the reason why a multifaceted approach to workload and recovery management is now considered best practice (23,25). This approach includes the collection and analysis of both subjective and objective measures, and the careful monitoring and optimization of the following key metrics:

Self-Reported Wellness: Identifying athletes' recovery issues and readiness to train/compete is often the starting point of a workload management program. A reliable and accurate method to identify athletes' readiness to train, the intensity of output that can be expected from the athletes during a session, and to measure the impact of non-sport stressors on the recovery process is to ask athletes to complete a short pre-training wellness questionnaire (Figure 1) (8,22). Examples of such questionnaires include those proposed by McLean and Kellmann (11,15).

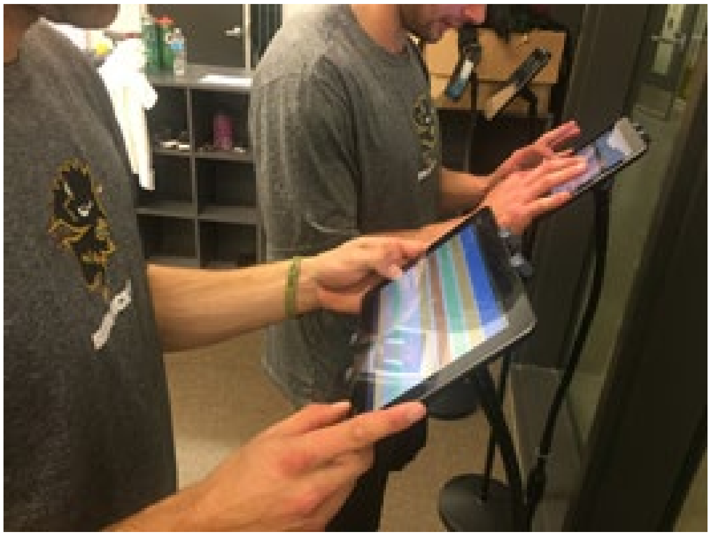

FIGURE 1. COLLEGIATE ICE-HOCKEY PLAYERS COMPLETING THEIR PRE-TRAINING WELLNESS QUESTIONNAIRE

Poor wellness scores indicate potential psychological or physical under-recovery and may lead to adjustments to the training or competition program. Self-reported wellness questionnaires are key injury prevention tools, and should be used to guide the adaptation of training and competition loads (25).

Chronic Load: This is the average weekly load (load = duration x sRPE) and is typically measured over the previous four weeks (7). It represents the level of load that athletes are used to. Usually, the higher the chronic load, the more fit the athlete. In some situations, chronic load can be calculated using exponentially weighted moving averages (17). Chronic load can also be tracked for periods longer than four weeks (1).

Acute Load: The acute load represents the cumulative load of the current week (7). Usually, exhausted athletes have higher acute load (compared to chronic load). In some situations, acute load can also be calculated using shorter periods (e.g., three days) (1).

Acute:Chronic Workload Ratio: The acute:chronic workload ratio (ACWR) measures the relationship between acute load (typically the current week load) and chronic load (typically the previous four-weeks average load) (7,9,17). Monitoring the ACWR helps to keep a player's workload in the "high-load, low-risk zone" (0.8 – 1.3). When ACWR is too low (less than 0.8) or too high (1.5 or more), risk increases and workload may need to be adjusted (Figure 2).

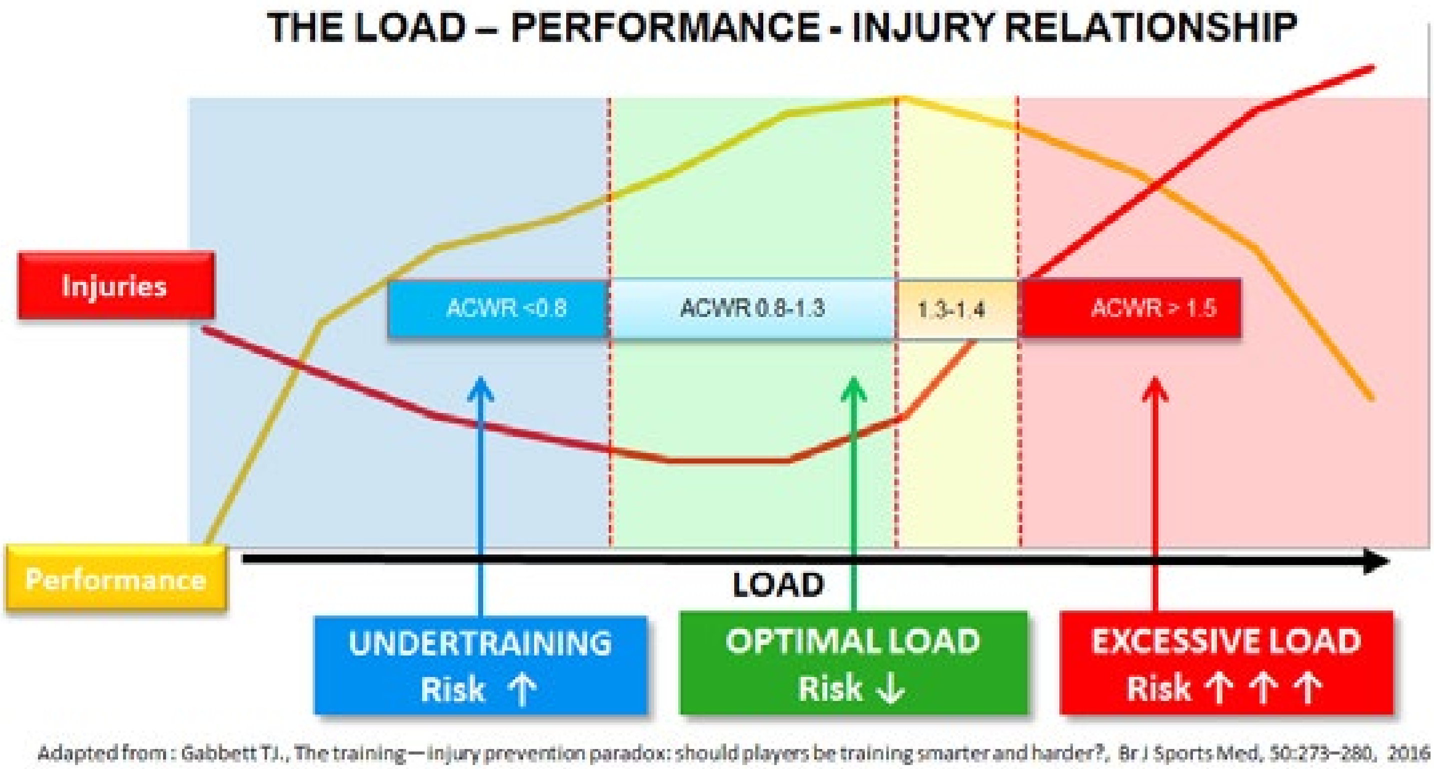

FIGURE 2. THE ACWR AND LOAD-PERFORMANCE-INJURY RELATIONSHIP

Freshness Index: The freshness index represents the difference between chronic and acute load or between "fitness" and "fatigue." A positive freshness index indicates an unloading phase where low fatigue and good performance levels are to be expected.

Week-to-Week Load Increase: This represents the percentage of load increase from one week to the next. Studies have shown a large percentage of injuries are associated with rapid changes, or "spikes," in weekly loads (7,19). When load increases by ≥ 15% from the preceding week, the risk of injury increases from 10% to almost 50% (7). Monitoring week-to-week changes for spikes in load, combined with limiting load increases to < 10% per week, plays a crucial role in injury prevention.

Monotony Index: The monotony index measures the fluctuation of daily internal load within the week. Intensive training combined with a high monotony index (> 2) is an important risk factor for illness and overtraining (5).

Personal Feedback: Personal oral or written feedback from the athlete can help identify potential motivation, stress, fatigue, and training issues. This is crucial information and can easily be overlooked by busy strength and conditioning coaches. When an athlete reports negative feedback, it must be taken seriously, as it could be the symptom of larger underlying issues, such as loss of interest/motivation, issues at home, burnout, etc.

Enjoyment with Training: Enjoyment with training and competition activities should be carefully monitored and maximized for two main reasons: 1) enjoyment is an important determinant of intrinsic motivation, which directly predicts effort and persistence (6); and, 2) a lack of enjoyment is associated with staleness and burnout (3). To maximize athlete engagement, motivation, and performance, strength and conditioning coaches are encouraged to create environments that allow athletes to have an enjoyable sport experience.

Other Useful Measures: When adequate equipment is available, additional daily tests of neuromuscular fatigue can provide useful information about neuromuscular recovery and/or injury (15). Results of these tests allow strength and conditioning coaches to manage athletes on an individual basis and based upon their training and recovery status.

PUTTING IT ALL TOGETHER

Figure 4 illustrates the integration of all metrics and the decision-making process. This model may be used as a general template of practice in establishing an evidence-based workload management program.

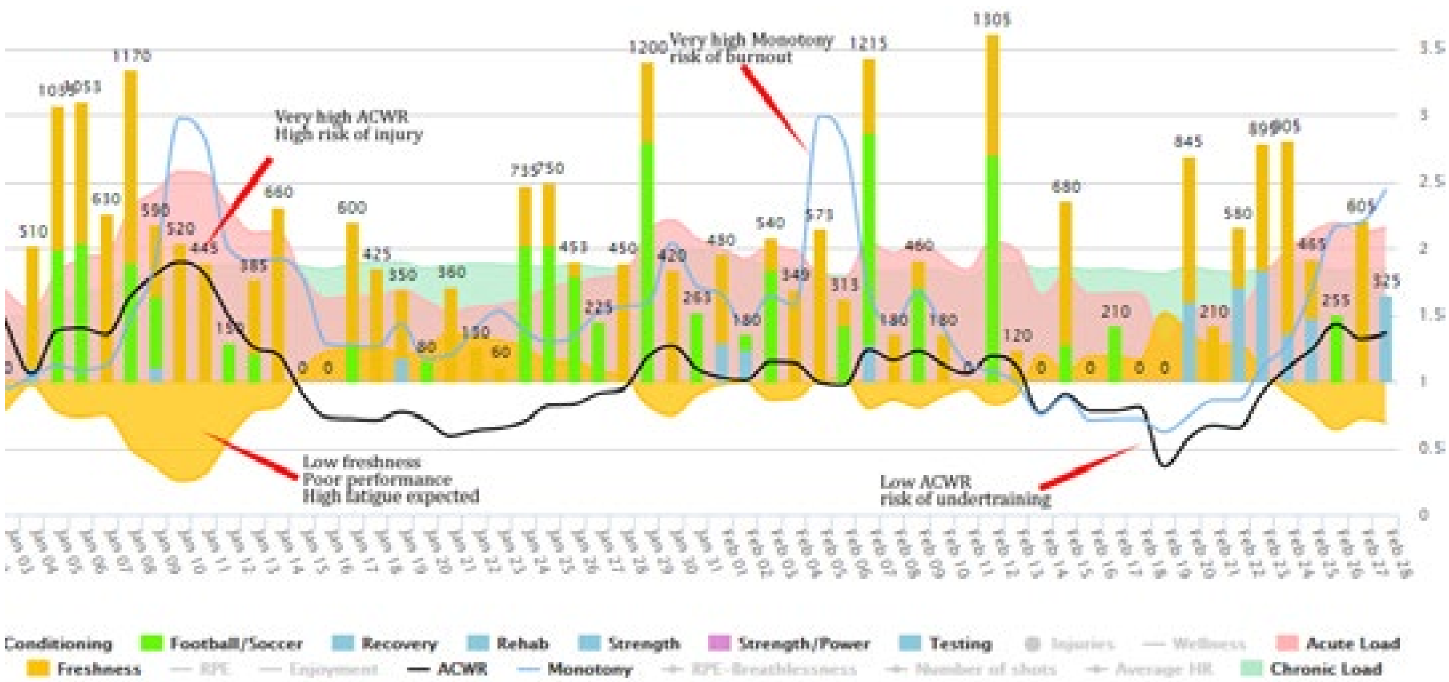

FIGURE 3. EXAMPLE OF WEEKLY CHANGE IN ACUTE AND CHRONIC LOADS, ACWR, MONOTONY, AND FRESHNESS INDEXES

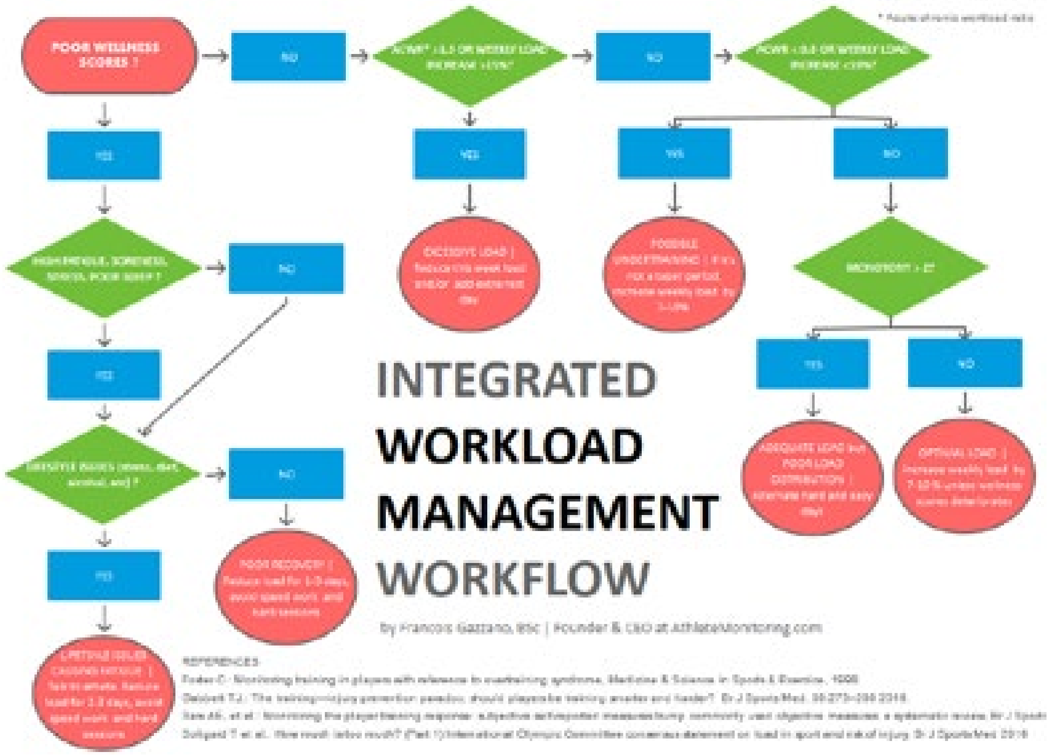

FIGURE 4. THE INTEGRATED WORKLOAD MANAGEMENT WORKFLOW

CONCLUSION

Managing workload and optimizing athlete performance while promoting injury-free participation is relatively simple. To ensure athletes optimize performance and minimize injury risk, the following tips are advised:

1. Start with the right tools
2. Monitor the key metrics
3. Increase weekly loads progressively
4. Avoid spikes in load
5. Alternate between hard, moderate, and easy training days
6. Use athletes' wellness data to guide daily load adjustments
7. Proactively manage training and competition loads during stressful periods
8. Make sure athletes have an enjoyable sport experience

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PROXIMAL POSITION DICTATES HIP PERFORMANCE AND HEALTH

GREG SPATZ, DPT, PT, PRC, CSCS, TREVOR RAPPA, DPT, PT, PRC, CSCS, AND DOUG KECHIJIAN, DPT, MA, PT, PRC

INTRODUCTION

Performance training programs typically include methods to improve the desired physiological qualities of speed, power, strength, and energy system development (amongst others) that are most applicable to the relevant sporting actions. While implementing these methods, athletes must manage challenges, such as maintaining orthopedic health. This article will provide strength and conditioning coaches with strategies to address hip mobility limitations that may lead to lumbar spine and femoral acetabular issues. These issues might include low back pain and related injuries (e.g., spondylolisthesis, facet joint pathology, and sacroiliac joint dysfunction), and hip or knee related injuries (e.g., anterior cruciate ligament [ACL] injury, femoral acetabular impingement, and hip labrum pathology). Pain, pathology, and performance in the distal segment of a joint articulation should not be regarded as distinct from its positional relationship to the proximal segment (1,2,3,5,8).

LUMBAR-PELVIC-FEMORAL MECHANICS

Osteokinematics (gross joint movements, such as extension, flexion, adduction, etc.) of the hip joint are such that as an athlete descends into a deep squat or decelerates to change directions, the femur relatively rotates internally and flexes (relative to the acetabulum when standing) (4,5). The arthrokinematics (small joint surface movements in a specific direction described as rolling, sliding, gliding, or spinning) at the joint interface are such that during squatting or change of direction movements, the femoral head rolls medially while sliding posteriorly and inferiorly (4). A restriction in these arthrokinematics could be a limiting factor to full hip mobility and may be due to the proximal joint position (1,2,4,7,8). Without favorable proximal acetabular position during these movements, the anterior/medial/superior rim of the acetabulum (when squatting or moving multi-directionally) can encapsulate the femoral head sooner than it should and may limit full mobility (2,8). A lack of full mobility in this context could expose athletes to orthopedic issues or overuse injuries over time (2,5,8). Oftentimes, athletes who have difficulty squatting to sufficient depth will present with limitations in hip mobility in the ways described above: hip internal rotation and flexion.

PRIORITIZING PROXIMAL ORIENTATION

Mobility restrictions or decreased ranges of motion in ball and socket joints like the hip are often attributed to soft tissue or capsular adaptations in the distal segment. The positional relationship between the ball and the socket must be accounted for before assuming a mobility limitation is due to tissue restriction. Proximal joint position can dictate distal mobility (2,4,8). Think of the proximal segment of a joint as the doorframe and the distal segment as the door. Canting the doorframe in any direction without a compensatory shift in the door does not allow the door to completely shut or display its full excursion of motion. In this instance, oiling the door hinge is not likely going to enable the door to shut completely. Similarly, not accounting for the orientation of the acetabulum when assessing performance at the hip joint can promote unsuitable interventions (traditional stretching or joint mobilizations in this instance). In this particular analogy, motor control at the pelvis in the frontal, sagittal, and transverse planes allows for less interference from the doorframe or acetabular rim.

SPORTS INJURIES AND PELVIC POSITION

In sport, a lack of hip internal rotation is associated with increased risk of injuries such as ACL tears and femoroacetabular impingement (1,3). From a performance standpoint, adequate hip internal rotation range of motion and control are necessary to safely and effectively get into a multi-directional athletic movement. In other words, an athlete needs to be able to load in order to explode. Additionally, hip internal rotation is necessary to reduce the rotational demand on joints above and below like the lumbar spine or knees in sports like golf, tennis, and lacrosse. One of the fastest ways to improve hip internal rotation is to give athletes strategies to combat anterior pelvic tilt. An anterior pelvic tilt has been shown to decrease hip internal rotation range of motion 11 – 15.9 degrees compared to posterior pelvic tilt (depending on the amount of hip adduction) (8). This increase can be what makes or breaks an athlete's health, both on the field and in the weight room. The following drills may help to combat anterior pelvic tilt and improve hip internal rotation and flexion.

DRILLS TO IMPROVE HIP INTERNAL ROTATION AND FLEXION

1. **Hamstring Bridge in Hip Internal Rotation with Shifting**: The purpose of this drill is to improve hip internal rotation and flexion mobility by facilitating a posterior pelvic tilt for both bilateral (squatting) and unilateral asymmetrical activities (multi-directional speed/agility) through hamstring and adductor activation.

    a. Begin with the feet elevated on a wall to about 90 degrees of hip and knee flexion with a six-inch object between the knees and the hips internally rotated (Figure 1).

    b. Pull the feet down along the wall to elevate the tailbone while keeping the back flat on the supporting surface (Figure 2). The athlete should feel their hamstrings engage.

    c. Squeeze the object between the knees while slowly shifting one knee higher than the other, alternating sides, for 2 – 3 sets of 30 repetitions (Figures 3 – 4). The athlete should continue to feel the hamstrings on both sides while alternating which adductor muscle is engaged with each shift. When shifting the left knee down, the athlete should feel the left adductor, and vice versa.

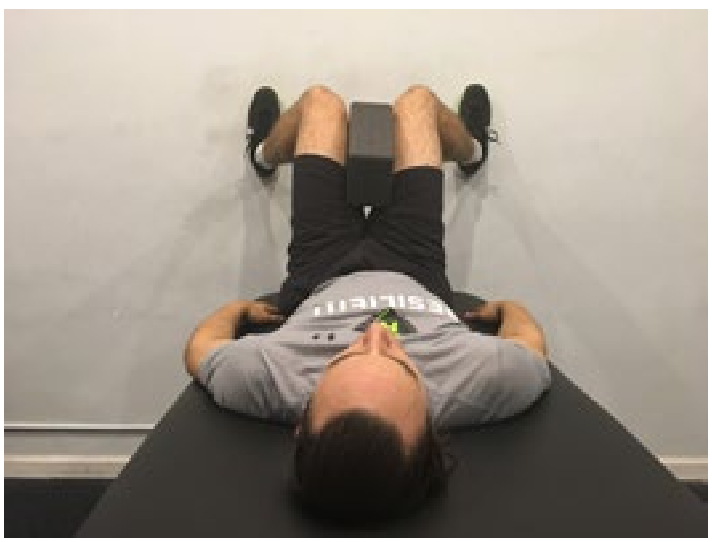

FIGURE 1. STARTING POSITION FOR HAMSTRING BRIDGE IN HIP INTERNAL ROTATION WITH SHIFTING

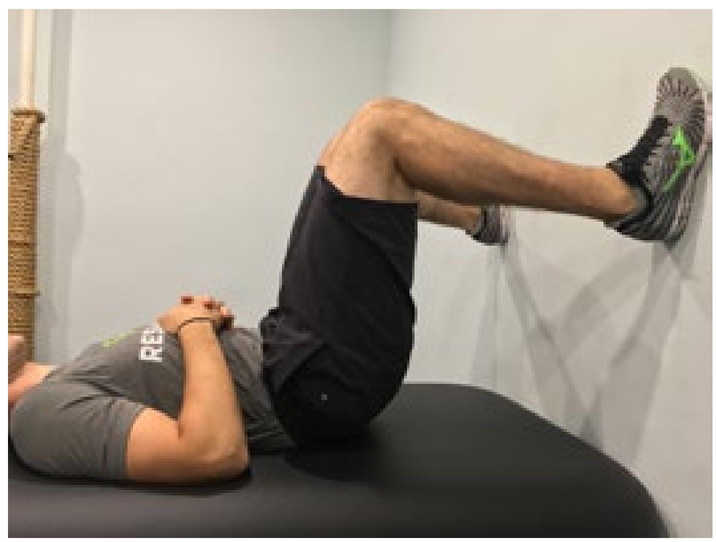

FIGURE 2. HAMSTRING BRIDGE IN HIP INTERNAL ROTATION WITH SHIFTING

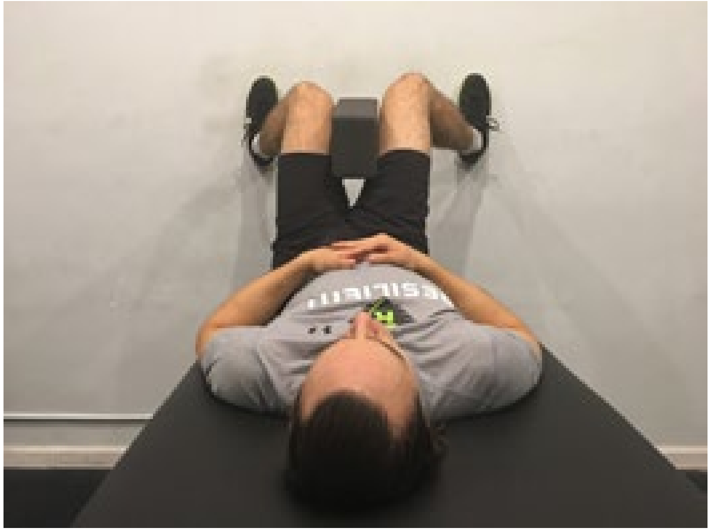

FIGURE 3. HIP SHIFTED LEFT FOR LEFT ADDUCTOR IN HAMSTRING BRIDGE IN HIP INTERNAL ROTATION WITH SHIFTING

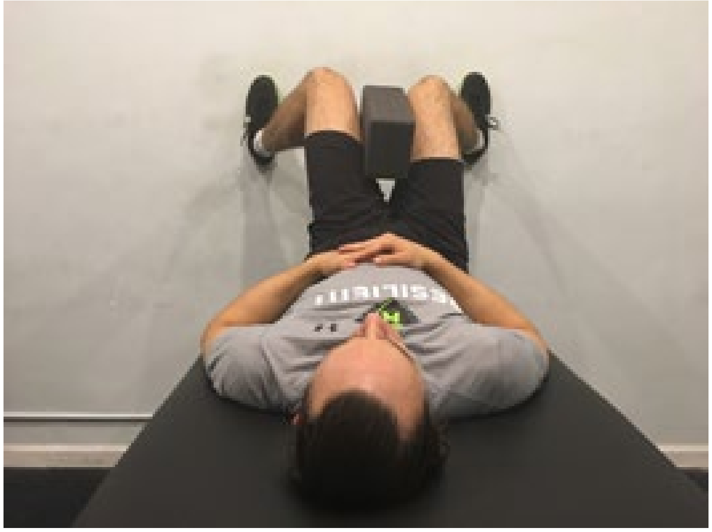

FIGURE 4. HIP SHIFTED RIGHT FOR RIGHT ADDUCTOR IN HAMSTRING BRIDGE IN HIP INTERNAL ROTATION WITH SHIFTING

FIGURE 5. STARTING POSITION FOR SQUAT-SEATED COUNTERWEIGHT BREATHING

FIGURE 6. ENDING/BREATHING POSITION FOR SQUAT-SEATED COUNTERWEIGHT BREATHING

2. **Squat-Seated Counterweight Breathing**: The goal of this drill is for the athlete to engage the hamstrings, adductors, and abdominal muscles in a position similar to the depth of a full squat in order to improve hip range of motion and motor control more specific to the loaded movement. Please note, this drill is not designed to mimic how a loaded squat should be coached as loading a flexed spine with knees driving medially may be unhealthy for the athlete. This is purely for improving the hip mobility related to squatting.

   a. Begin with a light (8 – 12-lb) object in the hands as a counterweight while sitting on a 12 – 16-in. high supporting surface (a large medicine ball works best) and a 6-in. object between the knees. Squeeze the object between the knees to engage the adductors (Figure 5).

   b. Roll backward on the ball to tuck the pelvis into a posterior pelvic tilt. Bring the feet back against the supporting surface, then pull the heels backwards as if performing a hamstring curl. The athlete should feel their hamstrings engage without losing the adductor activation.

   c. While holding the counterweight, reach the arm across the top of the knees and begin five slow breath cycles focusing on full exhalation. The athlete should feel their anterior ribs depress and abdominals engage while continuing to feel the hamstrings and adductors stabilize (Figure 6).

   d. One set of breathing should take about 60 s. Perform three total sets of breaths.

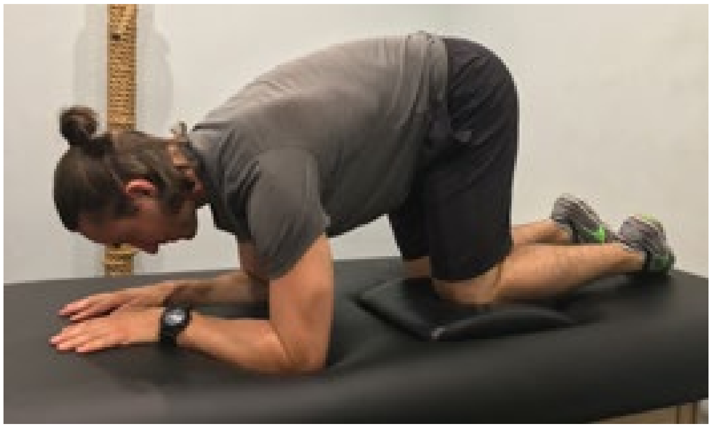

FIGURE 7. STARTING POSITION FOR POSTERIOR HIP CAPSULE STRETCH

FIGURE 8. STRETCHING/ENDING POSITION FOR POSTERIOR HIP CAPSULE STRETCH

3. **Posterior Hip Capsule Stretch**: The purpose of this drill is to stretch the posterior hip capsule to help improve hip internal rotation and flexion range of motion. For athletes who feel a deep, focal stretch in the back of the hip where a back pocket would be located, this stretch can be useful. Some athletes will not feel a stretch after replicating the position perfectly, which may indicate that they are not in need of this drill.

    a. The athlete should begin on a comfortable surface on their forearms and knees in a modified quadruped position with one knee elevated on a small pad and centered under the middle of the pelvis, keeping the shin facing downward and staying vertical running parallel to the spine (Figure 7). The elevated side is the capsule that will be stretched.

    b. Lift and place the opposite knee to the lateral side of the elevated leg's ankle without altering the elevated leg's placement. If stretching the left hip, angle the front of the right hip toward the left elbow (Figure 8).

    c. Without feeling a pinching or painful sensation in the front of the left hip, the athlete should feel a stretch on the posterolateral aspect of the hip near where the back pocket would be. If the athlete feels a pinching or pain anteriorly, try tucking the tailbone under and rounding the lower back, this should eliminate pinching right away. If the athlete is unable to proceed without a pinching or painful sensation anteriorly, discontinue this drill as it can lead to continued pain from bony impingement. Focus should be place on the other drills until a pain-free posterior hip capsule stretch can be achieved.

    d. Hold this stretch on each side for 2 – 3 min.

4. **Hip Flexor Couch Stretch with Hamstring Activation**: The purpose of this drill is to stretch the hip flexors and knee extensors while facilitating the hamstrings to help correct any anterior pelvic tilt. The athlete should feel an anterior thigh (quadriceps) stretch with hamstring activation to reciprocally inhibit the hip flexors and knee extensors. The goal should be to build up to a maximal isometric contraction without cramping, so the athlete should adjust the intensity of the isometric contractions as tolerated until able to complete the target amount.

    a. Using a box or bench with a height of about 24 in., place the top of one foot on the edge and the same sided knee on a supporting surface as close to the box or bench as possible. The athlete should place the opposite foot in front of their body at about 90 degrees of knee flexion.

    b. Place a small object between the elevated heel and same-sided posterior thigh and lean back into the object while performing a slight posterior pelvic tilt to feel the mid-thigh stretch (not the top/front of the hip as this may be the anterior hip capsule) (Figure 9).

    c. Complete 1 – 2 sets of 30 repetitions per leg of 5-s isometric hamstring contractions into the object while maintaining the posterior pelvic tilt.

FIGURE 9. STRETCHING/ENDING POSITION FOR HIP FLEXOR COUCH STRETCH WITH HAMSTRING ACTIVATION

CONCLUSION

The corrective drills listed above all follow a trend which aims to improve posterior hip capsule extensibility and hip internal rotation/flexion mobility. Additionally, there is an emphasis on promoting unloaded lumbar flexion and posterior pelvic tilting, which aids in orientation of the spine and pelvis towards a more neutral position, which is desirable for most performance training strategies (e.g., squatting and multi-directional activities). These exercises should not cause pain or discomfort, so if undesirable symptoms arise, the strength and conditioning coach and athlete should seek further consultation.

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PRACTICAL METHODS FOR THE STRENGTH AND CONDITIONING COACH TO DEVELOP STUDENT-ATHLETE LEADERSHIP—PART II

MICHAEL KASALES, MA, CSCS, RSCC, USAW-2, FMS

INTRODUCTION

This article is the second part of a two-part series that considers the potential role strength and conditioning coaches have in developing student-athlete leadership. Part I of this series provided a brief overview of leadership concepts and theory, presented definitions for student-athlete leadership and student-athlete leaders, and discussed the roles and relationship between the sport coach and the strength and conditioning coach. This article will discuss specific contributions the strength and conditioning coach can make towards student-athlete leadership development, as well as recommend some practical methods for developing student-athlete leadership.

Strength and conditioning coaches spend significant time with student-athletes during an academic year to improve their athleticism and prepare them physically to compete in their respective sports (11). During this time, the opportunity exists for the strength and conditioning coach to contribute to the development of student-athlete leadership skills. As discussed in part I, the strength and conditioning coach should coordinate with the sport coach before beginning any effort to develop student-athlete leadership skills. The strength and conditioning coach should understand the sport coach's philosophy and goals for the team, as well as the role student-athlete leaders will have on the team. Once the strength and conditioning coach understands the sport coach's vision, the contributions to developing student-athlete leadership will likely be well received by the student-athletes and appreciated by the sport coach.

STRENGTH AND CONDITIONING COACH CONTRIBUTIONS TO LEADERSHIP DEVELOPMENT

The strength and conditioning coach can potentially influence and have a direct role in developing student-athlete leadership skills. First, the strength and conditioning coach may serve as a role model and set the example of positive behavior for student-athletes (13). Second, the strength and conditioning coach can collaborate with student-athletes to establish strength and conditioning training goals, then provide instruction for student-athletes to achieve these goals (9). Third, the strength and conditioning coach can provide motivation to student-athletes through positive feedback on exercise technique and encouragement to provide maximal effort during strength and conditioning training (16). And lastly, the strength and conditioning coach can develop excellent rapport and trusting relationships with student-athletes (17). Through the execution of a strength and conditioning program, more practical opportunities can be presented to student-athletes to improve their leadership skills, such as a) assigning responsibility or designating leadership roles to the student-athletes to gain experience in leading and decision-making, and b) assigning senior student-athletes as mentors to younger student-athletes to gain experience in teaching and developing team cohesion (4).

ROLE MODELING

Role modeling should occur in clearly defined and positive ways (13). The values expressed by the strength and conditioning coach should reflect and reinforce those of the sport coach and the academic institution. This ensures there is no ambiguity or uncertainty in the direction the sport coach has established for the team, or in the values of the institution as a whole. As a role model, the strength and conditioning coach must strive to treat all student-athletes fairly and equally to ensure each student-athlete is afforded the same opportunities for development. Because each student-athlete is unique, with their own personal strengths and shortcomings, the strength and conditioning coach must recognize and respect these differences to avoid displaying favoritism towards any individual or group of student-athletes. Finally, the strength and conditioning coach should possess strong character and impeccable integrity as these attributes provide the "moral compass" required to be socially responsible (15). The strength and conditioning coach of poor character or with questionable integrity will be challenged to compel the student-athlete to develop his or her own character and integrity (15). A strength and conditioning coach should realize and accept the responsibility of being a role model. This responsibility and commitment can have a positive effect on the development of the student-athlete. Otherwise, the strength and conditioning coach may be missing an important opportunity to contribute to the development of the student-athlete (13).

GOAL-SETTING AND ACHIEVEMENT

Most strength and conditioning programs are based on clearly defined goals, typically a measure of intensity, volume, and duration. This provides the student-athlete with objective, daily performance goals. The ability to establish and achieve goals is an essential part of leadership development (9). The strength and conditioning coach should periodically review these goals with the student-athlete to ensure improvement in athletic performance. The strength and conditioning coach should ensure the student-athlete understands basic principles for resistance training (i.e. the difference in training variables for strength development versus power development) and training metabolic energy systems. Many young student-athletes may believe the bench press is the sole measure of athletic performance and strive to lift greater loads in a one-repetition maximum (1RM) effort; however, for many sports a 1RM bench press may not be the best predictor of athletic performance. As the student-athlete gains greater appreciation for the exercises that directly translate to athletic performance, the student-athlete can provide constructive feedback to the strength and conditioning coaches in order to refine or establish new performance goals. With this knowledge, a student-athlete may realize that established goals are achievable and potentially reinforce the goal-setting process for other aspects of life.

PROVIDING MOTIVATION

Many strength and conditioning coaches realize the importance of motivating student-athletes during training. Training requires student-athletes to work hard and often at near maximal levels of efforts to benefit from the training. The strength and conditioning coach can motivate student-athletes in several ways, such as providing timely and positive feedback, recognizing performance, and providing encouragement with enthusiasm (2). Positive motivation promotes the continued exertion of effort by the student-athlete, particularly during difficult tasks (3). Continued efforts by the strength and conditioning coach to motivate student-athletes often result in the student-athlete developing his or her intrinsic motivation (the desire to perform and participate in sport for the sheer pleasure and inner satisfaction obtained from the experience), which contributes to the development of leadership skills. Providing positive encouragement and motivation often develops the student-athlete's desire to train, and encourages positive interaction between the strength and conditioning coach and the student-athlete (6).

DEVELOPING RAPPORT AND TRUST

Given the amount of time spent together and the close interaction between the strength and conditioning coach and the student-athlete, the opportunity exists for the strength and conditioning coach to develop excellent rapport with the student-athlete (17). Having good rapport often leads to establishing a level of trust between the strength and conditioning coach and the student-athlete, further contributing to the development of the student-athlete (1,2,17). Allowing the student-athlete to voice opinions and concerns demonstrates a degree of social support towards the student-athlete which studies suggest is an important component in the coach-athlete relationship (2). In order to develop trust with the student-athlete, the strength and conditioning coach should be empathetic towards the student-athlete's opinions and work together to address issues, while maintaining a degree of discretion in divulging personal conversations to other coaches or student-athletes. Negative behaviors, such as intimidation, bullying, and threatening actions, should be avoided as this impedes building rapport and may lead to increased student-athlete anxiety and decreased athletic performance (1).

ASSIGNING RESPONSIBILITY AND DECISION-MAKING EXPERIENCE

Leadership development requires intentional efforts to assign leadership opportunities to student-athletes. Once these opportunities are assigned, instruction and feedback on leadership performance is necessary to fully benefit from the leadership experience (8,17). Most strength and conditioning programs include a wide variety of training modalities and equipment, which provide numerous potential opportunities for the strength and conditioning coach to assign leadership responsibility to the student-athlete. Effective leadership development should allow the student-athlete to practice leadership under the strength and conditioning coach's supervision, allowing the student-athlete to make meaningful decisions (7). Assigning a student-athlete the responsibility to develop and lead warm-up sessions, set up specific exercise equipment, demonstrate proper technique, or account for teammates are a few ideas available to the strength and conditioning coach to develop responsibility. The strength and conditioning coach must clearly articulate the standard to which the task is to be performed. The strength and conditioning coach should not assume the student-athlete fully comprehends all of the task requirements. Providing the student-athlete opportunity to ask questions or clarify requirements will reduce ambiguity and assist in the successful accomplishment of the task.

The strength and conditioning coach should avoid telling the student-athlete exactly how to accomplish the task, leaving some of the critical decision-making up to the student-athlete (except in cases where poor decision-making could result in the potential injury to the student-athlete and teammates). The student-athlete must be afforded adequate time and resources to prepare for and execute the activity or task. This may require the strength and conditioning coach to assign the responsibility several days or weeks in advance. The strength and conditioning coach should confirm and rehearse the activity or task with the student-athlete to ensure all aspects of the activity or task have been addressed. At the completion of the activity or task the strength and conditioning coach should provide feedback to the student-athlete on his or her performance. Feedback should focus on decisions and actions that contributed to success, as well as those decisions and actions that challenged the successful completion of the task. As a student-athlete demonstrates the ability to successfully accomplish assigned tasks and develops greater levels of self-confidence, the strength and conditioning coach should assign tasks with increasing levels of responsibility. Empowering student-athletes with decision-making opportunities provides the experiential learning that contributes to leadership development (7).

PEER MENTORSHIP

A final recommendation for the strength and conditioning coach to develop student-athlete leadership skills is assigning a more senior or experienced student-athlete the responsibility to mentor and encourage younger or less experienced student-athletes (9). Research suggests that peer mentorship can improve the leadership abilities of the mentor (12). As a mentor and developing leader, student-athletes can serve in several important roles. First, they provide advice and focus to teammates in order to accomplish team objectives. Second, they motivate and encourage teammates to perform at their best. Third, they serve to address the needs of their teammates and develop team cohesion (5). The interaction among teammates from different backgrounds is also important in developing respect for others, which is a desirable leadership attribute (10). As part of a strength and conditioning program, mentorship may be limited to activities in the weight room and on the practice field, but still provides valuable experience and opportunities to teach and motivate younger teammates.

CONCLUSION

Leadership development is a continuous learning process in which a student-athlete must evolve and practice a specific skill set to develop true aptitude (14). While many sport coaches realize the value of student-athlete leadership, numerous competing requirements prevent the sport coach from fully focusing on this aspect of student-athlete development. The strength and conditioning coach can potentially contribute to the development of student-athlete leadership skills. By sharing a common vision and understanding the values of the sport coach, the strength and conditioning coach can effectively direct efforts in accordance with the direction for the team set by the sport coach. The strength and conditioning coach's behaviors and actions influence the development of student-athlete leadership skills—serving as a role-model, establishing training goals with the student-athlete, motivating the student-athlete through positive feedback and encouragement, and developing rapport and trust with the student-athlete. The strength and conditioning coach also provides the student-athlete with practical opportunities to improve their leadership skills by providing leadership and decision-making experiences to the student-athlete and establishing a mentorship program to develop team cohesion. While not a traditional role or responsibility, the strength and conditioning coach can surely play a part and contribute to the development of student-athlete leadership.

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USING YOUR CREATIVITY AND KNOWLEDGE BASE TO IMPLEMENT LTAD— A SAMPLE LTAD PROGRAM AND LESSONS LEARNED

RICK HOWARD, MED, CSCS,*D, USAW

INTRODUCTION

Long-term athletic development (LTAD) provides a framework for youth coaches to create developmentally-appropriate strength and conditioning programs (6). LTAD addresses the needs of children (approximately ages 11 in girls and 13 in boys) and adolescents (approximately ages 12 – 18 in girls and 14 – 18 in boys), collectively referred to as youth (7). LTAD also addresses key differences in maturity, such as the difference between biological age (age since birth) and maturational age (a combination of cognitive, social, and motor skills, which collectively define athletic readiness) so that all fitness attributes can be trained throughout childhood and adolescence while athletic (sport) readiness is fostered (6,8,11). The central tenet of the National Strength and Conditioning Association (NSCA) 10 pillars of LTAD is that the health and well-being of youth is of critical importance (6). One of the greatest challenges facing coaches is creating safe and effective strength and conditioning programs based on the 10 pillars (6):

1. LTAD pathways should accommodate for the highly individualized and non-linear nature of the growth and development of youth.
2. Youth of all ages, abilities, and aspirations should engage in LTAD programs that promote both physical fitness and psychosocial wellbeing.
3. All youth should be encouraged to enhance physical fitness from early childhood, with a primary focus on motor skill and muscular strength development.
4. LTAD pathways should encourage an early sampling approach for youth that promotes and enhances a broad range of motor skills.
5. Health and wellbeing of the child should always be the central tenet of LTAD programs.
6. Youth should participate in physical conditioning that helps reduce the risk of injury to ensure their on-going participation in LTAD programs.
7. LTAD programs should provide all youth with a range of training modes to enhance both health- and skill-related components of fitness.
8. Practitioners should use relevant monitoring and assessment tools as part of a LTAD strategy.
9. Practitioners working with youth should systematically progress and individualize training programs for successful LTAD.
10. Qualified professionals and sound pedagogical approaches are fundamental to the success of LTAD programs.

A SAMPLE NOVEL APPROACH TO IMPLEMENTING LTAD

Using the following themes of the NSCA Position Statement on LTAD to guide the process (6):

1. Health and well-being is the central tenet.
2. Health-fitness and skill-fitness both must be developed.
3. Motor skills competence and muscle strength development are mandatory.
4. Movement quality must always be evaluated and addressed.
5. Performance increases and injury risk reduction are key elements of all programs.

The following represents an innovative approach that was used to implement an LTAD program in a health club, and includes the steps used for implementation.

1. **Invited all kids to participate in a fitness program to improve their sports performance**: Youngsters are acutely aware that fitness and sports participation are positively related (10). We provided the participants, parents, and sports coaches with information on the benefits of an LTAD approach. This included a flyer on the benefits of participating in youth sports (including better grades in school, better fitness and health, and greater self-esteem) and the NSCA LTAD online article for parents, which outlined the potential outcomes of improved performance and reduced risk of injury (1,9). From questions asked by parents and coaches, we were given the opportunity to provide an integrative neuromuscular fitness program to address health-fitness, skills-fitness, and motor skill abilities and decrements to kids that participated in sports camps throughout the year (4). A basic movement program using animal movement from different countries formed the foundation for 7 – 9 year-olds, and a games/fitness approach was used to help develop fundamental movement skills for 10 – 16 year-olds. Sport-relevant combine testing was conducted to establish baselines for sport camp program design (along with specific sport performance goals). For example, youth tennis players participated in a battery of tests including the spider test, which has shown to be a reliable test for youth tennis players (5). The spider test (also called the spider drill) measures tennis-relevant movement speed and agility from the center mark of the baseline to the athlete's left singles sideline and back, athlete's left corner of the service line and singles sideline and back, center of the service line and back, athlete's right corner of the service line and back, and athlete's right singles sideline and back. Other tennis-relevant tests included a medicine ball side toss (left and right), 20-m dash, vertical jump, broad jump, tennis shuffle test (from center service line to doubles

service line, to the opposite doubles service line, then back to center service line), and the Apley test (left and right).

2. **Engaged kids in the process of using the fitness center**: Several children and adolescents were asked what they thought the fitness center program should look like and what it should be called. Several had already participated in a golf initiative for golf etiquette, putting skills, and driving accuracy. They came up with the name "Beast Badge." They recommended that the program contain both a knowledge and skills component distinguished by age, with the skill component being competency performing the exercise rather than the number of repetitions or amount of weight lifted. The Beast Badge was divided into two groups: 10 – 11 year-olds and 12 – 15 year-olds, which matched the membership age categories for the club.

3. **Created the program to align with the 10 pillars of LTAD**: A program was created that assessed all kids equally. The first component was the etiquette and rules of using the fitness facility. The second component was the "ABCs of movement" (i.e., athletic stance, body awareness, and cardinal planes of movement), from which all other movements are derived (3). All movements were incorporated into both the sport camp model and the fitness center model.

4. **Incorporated health-fitness and skills-fitness movements**: At this point, three sequential levels of the Beast Badge were created for use in the fitness center, and reinforced during sport camps:

    a. Level 1 included strength movements in all three planes, and health-fitness and skills-fitness movements to create a circuit-style program of nine exercises. The circuit included bodyweight exercises, bands, kettlebells, and medicine balls.

    b. Level 2 included nine additional movements, explained why fitness is important, and discussed how to check for proper technique of workout buddies.

    c. Level 3 included instruction for all equipment in the fitness center and the basics of program design, including sport-relevant exercises.

    To illustrate, the checklist for Level 1 lunges was:

    - Stand with feet hip-width apart with a dumbbell in each hand and keep arms at the side of the body.
    - While maintaining an upright torso, step forward with one leg (about 3 – 4 ft).
    - Bend at the knee and lower the body until the back knee almost touches the ground. The forward knee should not pass beyond the toes. Both knees should make a 90-degree angle.
    - Push up and back off of the front foot to return to the start position.
    - Repeat with the other leg.

    Aspiring "Beasts" were asked questions either related to exercise technique (e.g., "what distance apart should your feet be when starting the lunge?" or "what is the name of the exercise where you step forward with one leg and bend at the knees toward the floor?") or fitness center rules (e.g., "what do you do with your weights after you complete an exercise?"). Participants were asked five questions and had an opportunity to adjust their technique or answer until correct.

5. **Recognition**: All junior members that completed a level of the Beast Badge received a wrist band that identified which level and which age group. The band read "Certified Beast." The wrist band needed to be worn in the fitness center at all times. Parents received a copy of the Beast Badge packet that informed them what each "Beast" was able to do, when they may use the fitness center, and under what conditions (10 – 11 year-olds must be accompanied by a parent and 12 – 15 year-olds can use the fitness center on their own).

LESSONS LEARNED

There were several lessons learned in the pilot stage of the Beast Badge and summer camp program:

BEAST BADGE

Junior members earned their Beast Badge in the club's fitness center, which included a variety of cardiovascular equipment, selectorized machines, suspension training, dumbbells, kettlebells, medicine balls, ladders, bands, and plyometric boxes. No modifications of equipment were needed, as "Beasts" were instructed that if they did not fit any piece of equipment, they would be shown proper use once they could fit in the equipment correctly. Junior members could obtain their Beast Badge in an individual session or in groups. A nationally-certified strength coach worked directly with youth for every session and adults were present in the fitness center (parents were encouraged to attend). The awareness by adult members that the youth were learning how to properly train was overwhelmingly positive. Integrating fitness into all areas of the fitness center was an effective strategy for both kids and adults. The overall goal was for the "Beasts" to build their movement vocabulary using a variety of equipment, as suggested by Faigenbaum and Myer (2). One lesson learned was to provide more movements initially in the Level 1 program and then build on those movements. The second lesson learned was to encourage parents even more to observe or be in the facility while the youngsters were training.

SUMMER CAMP

The facilities for the summer camps were most often the indoor tennis courts, which provided plenty of space for different movements, games, and resistance training activities. From tug-of-war and light tire flips to kettlebell challenges and agility drills within the tennis court, summer camp athletes learned how much fun exercise could be and that there was something for everyone. We conducted a trial tennis combine towards the end of the summer to serve as a baseline. One lesson learned was to plan to re-evaluate every season, track the test data, and begin to track attendance data. The second lesson learned was to provide sport-relevant combine-type testing for a variety of sports for both youth and adults. The third lesson learned was recognizing that not every coach understands how to best train youth, so more professional development in this area is needed.

PATH FORWARD

The next phase includes several impactful components to increase the success of the program:

- Expand the innovative LTAD programming with increased opportunities to participate. Targeting ages 6 – 9 beyond sport camp is a priority for establishing an interest in fitness, promoting the positive relationship between fitness and sports participation, and developing lifelong healthy habits.
- Fitness competitions/combines for all age groups are being scheduled for the winter and summer, and will include a process (technique) and product (peer-matched performance standards) assessment for each movement.
- Additional sport camp opportunities that meet more regularly (most sessions are twice a week for 30-min each) are being advocated.
- Engaging "Beasts" to help lead instruction for those seeking their Beast Badge is being implemented (peer-to-peer training).
- Staff development for the coaching staff that includes best practices for coaching the youth population.

As always, information on LTAD, safe and effective training techniques for youth, sport performance strategies, and lifelong performance are shared with parents, coaches, and youth.

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DRYSIDE TRAINING FOR SWIMMERS—USING ROPES TO INCREASE MUSCULAR ENDURANCE

CHRIS MYERS, MS, CISSN

INTRODUCTION

Balancing dryside and wetside training for swimmers is challenging. United States of America Swimming defines dryside training as "any training a swimmer performs outside the pool," (10). Whereas, wetside training is any training a swimmer performs in the pool. Resistance training is a great way to create an effective dryside training program. A good swimming coach will find a way to balance and complement these two modalities of training.

When coaches and swimmers think of dryside training, many think of resistance training to improve muscular strength, not endurance. Specifically referring to the front crawl stroke, muscular hypertrophy-focused resistance training can lead to small improvements in sprint performance with little to no improvement in endurance (2). The result is essentially the same across all swim strokes. This outcome is not surprising due to the muscle fiber types being trained. During muscle building types of resistance training, Type IIa and Type IIb muscle fibers are the primary focus. Anaerobic muscle fiber types are designed for short, powerful bursts of force. These muscle fiber types are good for short distance swims. However, for longer events, such as middle distance swims, triathlons, and open water swims, the swimmer needs to build endurance. Type IIa and Type IIb muscles are not specifically designed for endurance. To increase muscular endurance, Type I and Type IIa muscle fibers need to be targeted.

MUSCLE FIBER TYPES

Three types of skeletal muscle fiber types exist within the human body. The fibers are identified based on myofibrillar-ATPase activity. The rate of reaction of the ATPase regulates the contractile "speed," thus determining the classification of the muscle fiber (1). The Type I fiber is considered to have a slow twitch speed, low twitch force, low fatigability, and is associated with endurance activity (7). Type IIa is classified as having a fast twitch speed, intermediate twitch force, and moderate fatigability (7). Further down the spectrum, Type IIb are categorized as having a fast twitch speed, large twitch force, and high fatigability (7).

The fatigue properties of these fiber types play an important role in skeletal muscle recruitment. In three separate experiments, Vollestad et al. confirmed the order of recruitment (7). This order is Type I, Type IIa, followed by Type IIb (1,7). This order of recruitment depends on the response to the load placed on the target muscle. By exploiting this order of recruitment, certain aspects of skeletal muscle physiology can be manipulated. For example, the exposure to the right type of endurance training stress, Type IIa muscle fibers will shift to mimic Type Ia characteristics (7). The same occurs with Type IIb beginning to mimic Type IIa characteristics (7). This fiber type shift can assist with increasing endurance performance if targeting through training protocols.

BACKGROUND

The front crawl (i.e., freestyle) stroke is a whole-body activity that requires a swimmer to use many muscles in his or her body. The pulling stroke of the front crawl creates the majority of the swimmer's propulsion (7,8). Additional propulsion is created by the kicking motion. Furthermore, the distance and intensity of the stroke determines the recruitment of certain skeletal muscle fibers. The focus of the remainder of this article is to review the front-quadrant biomechanics of the front crawl swim stroke and to introduce battle rope exercises to better strengthen the muscles involved with this stroke to improve endurance and power.

SECTION 1: FRONT CRAWL SWIMMING BIOMECHANICS

Range of motion of the shoulder comes from the connection of the glenohumeral joint and the glenohumeral fossa. The shoulder girdle is comprised of three bones (scapula, clavicle, and humerus). The shoulder girdle, along with several tendons, ligaments, and muscle groups, allow for the movement of the shoulder in a 360-degree motion (8). This movement allows for the front crawl stroke to occur.

The upper body front crawl stroke is broken into five phases. The phases are as follows: entry and stretch, catch, pull (downsweep), push (upsweep), and overwater recovery (5,10).

HAND ENTRY AND STRETCH PHASE (FIGURES 1 – 3)

During this phase, the arm is about to enter the water. This is considered the start of the stroke cycle. The arm is raised above the head and aligned slightly inside the shoulder. The middle deltoid, upper trapezius, and rhomboids are the primary movers for this motion (5). For elbow flexion to occur, the brachioradialis and biceps brachii are engaged. Shoulder internal rotation is driven by the subscapularis, pectoralis major, teres major, and latissimus dorsi (6). Finally, the pronation of the forearm is caused by the activation of the pronator teres and pronator quadratus (8).

Additionally, the arm is beginning to enter the water with forward momentum. The pectoralis minor and serratus anterior cause the scapula abduction within the shoulder girdle. The shoulder horizontal flexion is caused by the pectoralis major (clavicular head) and anterior deltoid (3,8).

FIGURE 1. HAND ENTRY AND STRETCH PHASE

FIGURE 2. HAND ENTRY AND STRETCH PHASE

FIGURE 3. HAND ENTRY AND STRETCH PHASE

CATCH PHASE (FIGURES 4 AND 5)
At this point, the arm has entered the water and completed its extension. For wrist flexion of this movement, the flexor carpi ulnaris and flexor carpi radialis are utilized. The flexor and extensor carpi ulnaris cause ulnar deviation, which results in an anterior twist to the ulna. Finally, the biceps brachii and brachioradialis cause elbow flexion (8,10). This action assists in the creation of the maximal amount of surface area for the forearm and the hand. The maximal usage of the arm's surface area creates maximum propulsion throughout the entire stroke cycle.

PULL PHASE (FIGURES 6 AND 7)
The motion, also referred to as the downsweep, of the arm during this phase causes the maximum amount of propulsion during the stroke's sequence. The arm is starting to make a downward sweeping stroke. Due to the curvilinear motion created within the shoulder, the wrist and hand naturally turn outward. The brachialis and biceps brachii cause the elbow flexion, while the flexor carpi ulnaris and the flexor carpi radialis cause the wrist flexion (8). Finally, the internal shoulder rotation is caused by the subscapularis, pectoralis major, teres major, and latissimus dorsi (5).

FIGURE 4. CATCH PHASE

FIGURE 5. CATCH PHASE

FIGURE 6. PULL PHASE

FIGURE 7. PULL PHASE

PUSH PHASE (FIGURES 8 – 10)

At the beginning of this phase, the arm reaches the deepest part of the sweep and begins swinging upward, also referred to as the upsweep. At this point, most of the work moves from the pectoralis major to the latissimus dorsi, subscapularis, and deltoids (5,8). Flexor carpi radialis, and extensor carpi radialis longus and brevis cause the radial deviation (8). The shoulder external rotation is caused by the infraspinatus and teres minor. Finally, the clavicular pectoralis major and anterior deltoid create the shoulder horizontal flexion (3,5,8).

Towards the end of the push phase, the arm is moving in an upwards direction. The shoulder girdle is at maximum extension which is controlled by the latissimus dorsi, supraspinatus, and deltoids (5). Simultaneously, elbow flexion is occurring. The primary mover for the elbow extension is the triceps brachii (8).

OVERWATER RECOVERY PHASE

This phase begins as the arm reaches the maximum extension and rotation of the shoulder girdle. To bring the arm back to a frontal position, the elbow needs to flex (8,10). Biceps brachii and brachioradialis cause elbow flexion (8). The early segment of the shoulder external rotation is created by the deltoids and the rhomboids (5). As the arm reaches the peak of the rotation (i.e., 12 o'clock position), the shoulder rotation is controlled by the upper trapezius, middle deltoid, serratus anterior, and infraspinatus (5,8). The deltoids, rhomboids, subscapularis, and serratus anterior are fully engaged as the arm rotates and is about to enter the water (5,8).

SECTION 2: DRYSIDE MUSCULAR ENDURANCE TRAINING

When considering dryside training events, the training must be tailored to target and improve specific muscle fibers. In this case, Type I and Type IIa are the targeted groups. The following exercises are designed to promote improving endurance properties of the Type I and Type IIa muscle fibers. Type IIa will gain the most benefit; however, Type IIb muscle fibers will benefit as well.

A new type of exercise has emerged over the past few years to achieve the desired training effect: battle rope exercises. Battle rope exercises offer a new and exciting venue for resistance training. These exercises can be performed at the side of a pool and can be easily incorporated into a regular swim workout. A rope is the only piece equipment the athlete needs. A battle rope is typically a 1 ½ – 2 in. diameter rope ranging from 30 – 100 ft in length, and the weight of the rope often ranges from 50 – 75 lb.

When using a battle rope, an athlete can perform strength or endurance training exercises. The goal is to target the muscles used in the front crawl stroke through endurance-focused resistance training. This type of training is characterized as low-weight and high-repetition exercise (3). Because increasing endurance is the primary goal, using a lighter rope, to increase training duration (i.e., 1.5-in. diameter and 30 – 50 ft in length) would be ideal.

FIGURE 8. PUSH PHASE

FIGURE 9. PUSH PHASE

FIGURE 10. PUSH PHASE

The battle rope forces the swimmer to use the stabilizer muscles in addition to the prime mover muscles. Battle ropes have inherently unstable characteristics, especially with the exercise being performed. These characteristics cause the athlete to use stabilizer muscles to keep the rope moving in the proper direction. The following suggested exercises are designed to target the muscles of the upper back, shoulders, arms, and core to increase endurance for the front crawl swim stroke. Remember, the goal is to perform each exercise for 1 – 2 min in length. By using a lighter rope and increasing the duration of the exercise, the athlete can focus on the bioenergetics and particular muscle fiber types to increase muscular endurance.

PROPER STANDING POSITION (FIGURES 11 AND 12)

The swimmer should stand with their feet shoulder-width apart. Their knees should be slightly flexed and their weight centered. This stance lowers the athlete's center of gravity and creates a stable platform to perform the exercise. This stance is used for all of the following drills.

BATTLE ROPE DRILLS

ALTERNATING WAVES (FIGURES 13 AND 14)

To perform this drill, take the end of the rope in each hand and perform up and down motions. Each end of the rope is gripped with an overhand grip. The upper part of the stroke ends at shoulder level, while the lower level ends at the waistline. This limited range of motion results in smaller and faster arm movements. This motion mimics the similar range of motion that occurs throughout the catch and pull phases. The resulting alternating strokes cause the rope to produce alternating vertical waves.

This exercise primarily works the rhomboids, deltoids, biceps, and triceps. Additionally, the muscles of the shoulder girdle must assist in stabilizing the rope.

FIGURE 11. PROPER STANDING POSITION FOR BATTLE ROPES

FIGURE 12. PROPER STANDING POSITION FOR BATTLE ROPES

FIGURE 13. ALTERNATING WAVES

FIGURE 14. ALTERNATING WAVES

DOUBLE WAVES (FIGURES 15 AND 16)
This exercise parallels the alternating waves, but the swimmer holds the rope ends together with both hands. The up and down arm motion is the same as with alternating waves. The arms range of motion move from the shoulder to the waistline. Because the rope ends are held together and the arms are near the centerline of the body, different muscle groups are trained than compared to those with the alternating waves exercise.

During this exercise, the swimmer is training the shoulder girdle muscles, biceps, triceps, and flexor and extensor carpi ulnaris. However, the main difference between the two exercises is that the swimmer needs to keep the abdominal muscles stable to keep good control of the rope.

SIDE-TO-SIDE WAVES (FIGURES 17 AND 18)
In this exercise, the swimmer holds an end of the rope in each hand as in the alternating waves drill. The rope is then held at waist level. The swimmer twists and swings the arms from side to side. In doing so, the swimmer creates a horizontal double wave with the rope.

To create this motion, the swimmer must use their upper body muscles. Besides using the deltoids and rhomboids of the upper back, the swimmer must use their latissimus dorsi, external abdominal obliques, and abdominals to maintain stability.

FIGURE 15. DOUBLE WAVES

FIGURE 16. DOUBLE WAVES

FIGURE 17. SIDE-TO-SIDE WAVES

FIGURE 18. SIDE-TO-SIDE WAVES

THUMBS UP DOUBLE WAVES (FIGURES 19 AND 20)

To correctly perform this exercise, the swimmer must hold each end of the rope with the thumbs upward. The motion for this drill is the same as the double wave exercise.

The change in hand position allows for training of additional muscle groups. This drill works the swimmer's latissimus dorsi, triceps, and upper muscles of the shoulder girdle. Additionally, the rectus abdominus is used to stabilize the body during the drill.

DOUBLE CIRCLE WAVES (FIGURES 21 – 23)

The rope is held as described in the alternating waves drill. The swimmer swings each end of the rope in a circular motion. One arm will go in a clockwise motion, while the other will go in a counter-clockwise motion. The ropes are swung similarly to a "double dutch" jumping rope exercise. The swimmer works the same muscles described in the side-to-side waves drill.

FIGURE 19. THUMBS UP DOUBLE WAVES

FIGURE 20. THUMBS UP DOUBLE WAVES

FIGURE 21. DOUBLE CIRCLE WAVES

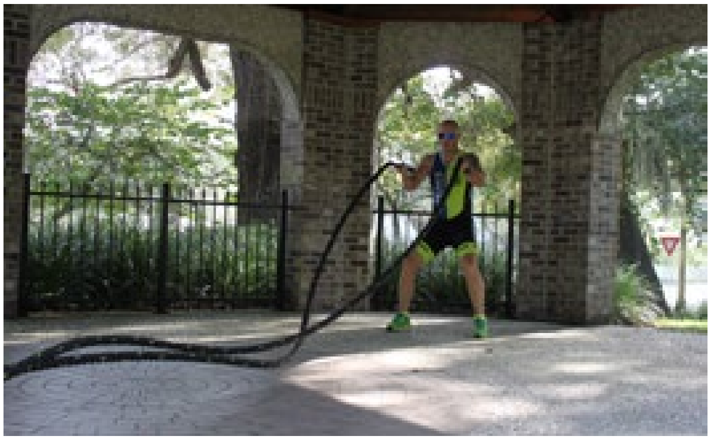

FIGURE 22. DOUBLE CIRCLE WAVES

FIGURE 23. DOUBLE CIRCLE WAVES

SECTION 3: SAMPLE DRYSIDE TRAINING USING BATTLE ROPE DRILLS

The focus of these drills is to train and develop the swimmer's Type I and Type IIa muscle fibers that are involved in the six phases of the front crawl pulling stroke. The following sampling of battle rope drills can be used as part of any dryside training plan to assist in developing a swimmer's muscular endurance. The rest interval between exercises should be 2 – 3 min.

1. Alternating waves (3 x 1 min) with 30 s rest between repetitions.
2. Side-to-side waves (3 x 1 min) with 30 s rest between repetitions.
3. Double waves (3 x 1 min) with 30 s rest between repetitions.
4. Double circles (3 x 1 min) with 30 s rest between repetitions.
5. Thumbs up double waves (3 x 1 min) with 30 s rest between repetitions.
6. Double circle waves (3 x 1 min) with 30 s rest between repetitions.

The key principle is to train the musculature for endurance. The longer the swimmer performs the exercises, the more Type I and Type IIa muscle fibers are trained. The number of repetitions and time can be tailored to each swimmer's skill level and age.

As previously described, this program is designed for longer swim events (i.e., 500 m or longer). However, the variable of intensity and exercise duration can be manipulated to make the suggested resistance training regimen more strength based. Using a heavier rope and shortening the exercise duration (i.e., from 1 min to 30 – 45 s) can promote increases in strength. This type of training would be beneficial to promote increases in stroke power (i.e., propulsion) in swim sprint events (i.e., less than 400 m).

CONCLUSION

Many different forms of battle rope drills are used to train both muscular strength and endurance. The exercises mentioned in this article are a small sampling of the drills available to the strength and conditioning coach when using rope drills. Drills mainly translate to the direct training of muscles used by a swimmer who utilize the front crawl stroke. By adding these movements to a swimmer's dryside training, swimmers gain muscular endurance that will complement wetside training. These exercises can be used for other swim strokes as well. The strength and conditioning coach needs to identify the core muscles involved with the primary movement for the target swim stroke.

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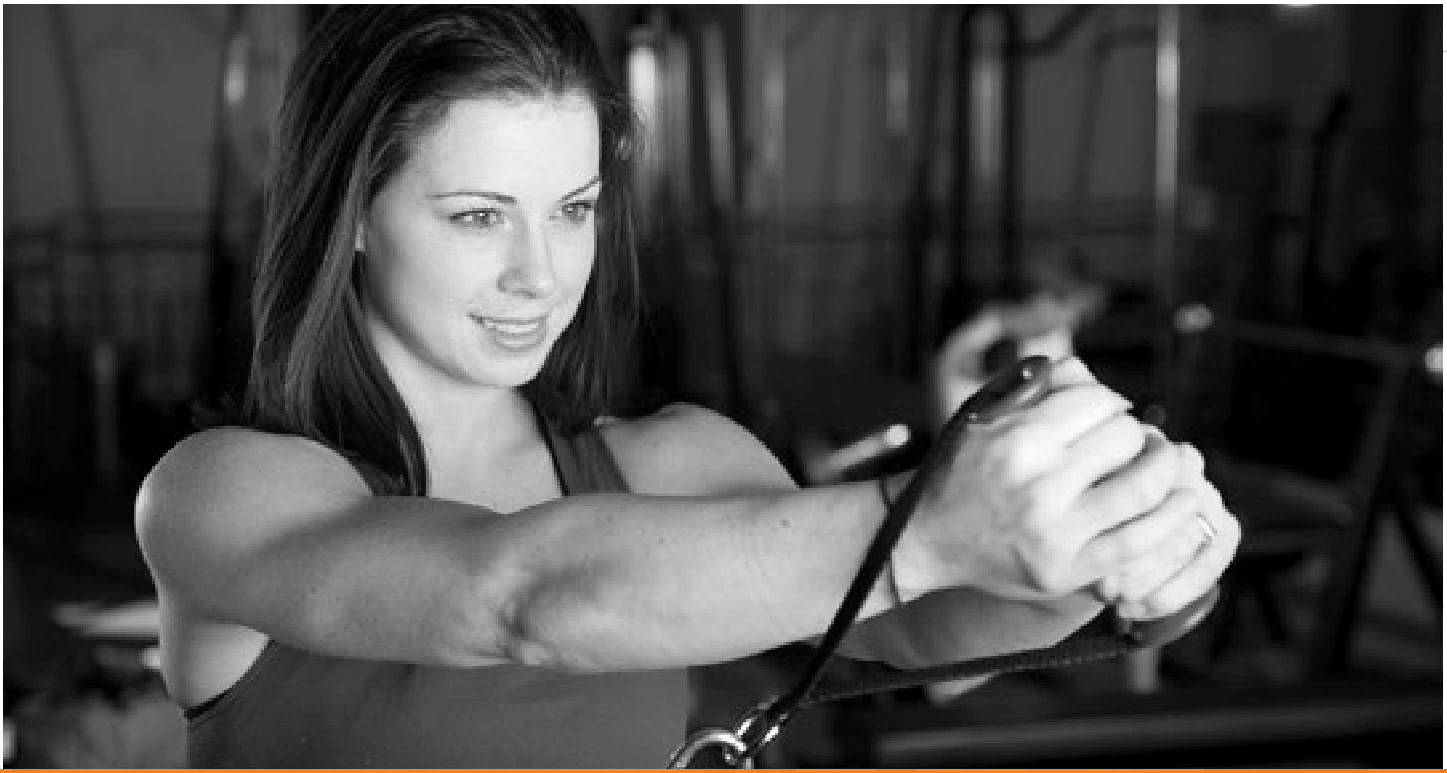

THE PERCEPTION AND PROGRESSION OF THE FEMALE ATHLETE

NATAJAH GARCIA, ALICE GARZA, ANDRES GARZA, AND ALYSSA GONZALEZ

INTRODUCTION

Female athletes in the United States have made great progress in sport since Title IX was enacted in 1972 (3,4,7,8,9,10,11,12,16). Many female athletes went from appearing in "gender appropriate" sports such as gymnastics, figure skating, and ballet to competing in contact sports, including but not limited to: wrestling, basketball, hockey, and soccer (3,4,10,11,12). Did female athletes revolutionize themselves throughout the last 45 years or have they always had it within themselves to compete in sports that have been dominated by their male counterparts? It should be recognized that female athletes have broken out of the box they had been placed in by their peers. However, despite the progress they have made, female athletes have yet to gain full recognition for their athleticism and their achievements. The purpose of this article is to break down the stigma female athletes have received over the years and shine light on the differences that make female athletes a reward to train.

THE PERCEPTION OF THE FEMALE ATHLETE

Women's sports have largely been overlooked and undervalued post Title IX in 1972. The disparity in media coverage and focus on male sports compared to female sports is highly evident (2,6,7,13,15). Male sports largely dominate the sports media coverage, not only in individual sports but also in team sports (7,9,11,12,13,15). The perception of female sports is often looked at as novelty and "cute," but the amount of work and the level of success that women have obtained in sports can often be greater than those accomplishments made by male athletes (1,2,5,7,8,9,10,11,12,13,15). For instance, in the 2012 London Olympics, 63% of the Gold medals and 56% of the overall team medals taken home by Team USA were won by females.

We can compare a few of the more popular sports in terms of male success versus female success. Every year, National Collegiate Athletic Association (NCAA) Division I basketball hosts a tournament that crowns a National Champion for both female and male teams. While the female tournament is often broadcasted solely on paid cable television, the men's games can be viewed on large networks. One team has dominated the NCAA Women's Basketball tournament over the past 10 – 15 years. The University of Connecticut's women's basketball team has won 11 national championships, including consecutive titles from 2013 – 2016. The University of Connecticut's women's basketball team holds the two longest regular season winning streaks. The first, a 90-game winning streak lasting from 2008 – 2010, and the most recent was a record setting winning streak of 111 games, which ended March 31, 2017 (1). These achievements have been largely overshadowed because the media pushes March Madness with a focus on men's basketball and brings attention to the "create your own bracket and win a prize" contest.

Another example is the global sport of soccer. The United States men's soccer team is not known as a contender year in and year out, but they seem to dominate the headlines when they achieve relatively minimal success. On the other hand, the women's USA soccer team has won the Fédération Internationale de Football Association (FIFA) World Cup three times (1991, 1999, and 2015) and has been Olympic champions four times (1996, 2004, 2008, and 2012). The women's national soccer team is known and recognized as a powerhouse in the women's soccer world, but they are often overlooked and underappreciated on the home front. When female athletes do receive media coverage, they are often described in terms of their physical desirability to men or in their domestic roles as wives and mothers (2,6,7,10,11,13,15). Sports commentators are more likely to speak of a female athlete's male coach and his accomplishments or the athlete's famous husband while she is onscreen instead of praising or simply recognizing her athleticism. Even elite-level female athletes who have competed for years will be described with phrases such as "she plays like a man" suggesting that she may not be a woman at all because of how powerful or precise her skills are. It is as if female athletes have the privilege of competing in sports but will continue to only be labeled by their gender because females will never be as athletic as their male counterparts. As a result, one overlooked topic is understanding and highlighting what makes female athletes look within to find the motivation to participate in sport.

TRAINING FEMALE ATHLETES

What motivates an individual to participate in competitive sports has been researched and analyzed with regard to gender differences (3,5,8,9,11,14,16). Motivation for all athletes can be described as "the foundation of all athletic effort and accomplishment," (9). Without motivation, it would be difficult for athletes to continue to develop their skills and achieve their goals. Over the years, research has identified how both female and male athletes differ in terms of their motivations for involvement in competitive sports (3,5,8,9,11,14,16). Researchers have provided evidence showing that female athletes are more intrinsically motivated than male athletes (3,8,9,14,16). Intrinsic motivation can be described as doing an activity out of pure interest and for pleasure or satisfaction that is derived from simply performing the activity. Therefore, coaches will often experience female athletes practicing for their sport for the pleasure of constantly surpassing themselves and their previous accomplishments. Researchers also found that female athletes exhibit more identified regulation than their counterparts; that is, they value and judge behavior as being important and therefore will perform it out of choice (3,8,9). For example, the female athlete may say that she has chosen to go to practice because it is something important to her, unlike the male athlete who may go to practice to show others how good he is or to gain praise from coaches and trainers. Understanding these overall differences can give trainers, coaches, and physical educators better insight into what drives female athletes. Due to these developmental differences and given what we know about motivation, a sensible question to consider is when female athletes exhibit these internal motivational qualities and how to leverage this phenomenon to enhance their athletic performance (3,4,9,14,15,16).

A study found that as early as middle school years, females and males differ in regards to their motivations for involvement in sports and physical activity (16). The findings of the study indicated that the girls cited social and skill benefits, competition, and fitness as high priority for involvement; however, the boys indicated a higher concern and attraction solely to competition. In short, the males were driven by competition while the females were more attracted to the social benefits associated with their sports (3,16). Body-related factors and social factors are stronger motives for women and competition motives are more valued by men in regards to participation in sports and physical activity; these differences are likely due to societal expectations of proper gender roles for men and women (2,3,7,9,10,11,12,16). If social benefits and enjoyment of sport and exercise rank high in the motivational factors for female participants, then the progression of female athletes while they are still developing may depend on how others approach guiding them to success. With regard to studying motivational factors of college women versus men in regards to sports participation and exercise, findings indicated that men were more concerned with ego-related factors of participation (3,8,9,14,16). This included factors such as strength, competition, and social recognition. The male athletes preferred to participate in sports and exercise for the prestige associated with being an athlete. As for the women, enjoyment was a high motivational factor for participation in sport and exercise.

Personal relationships seem to be a motivational factor for female athletes. Personal relationships include coaches and athletic teammates. Females tend to appreciate a nurturing family environment and camaraderie. Therefore, coaches and trainers must remember that each person is an individual and by focusing on providing positive feedback, good listening, and constructive criticism, the coach will continue to develop positive self-perception and confidence in the athlete. With the support of continuous team building activities, female athletes will be motivated by their personal relationships to contribute to their team more than they would if they were exposed to a negative environment and did not have an existing relationship with their coaches, trainers, or teammates.

The female athlete's enjoyment of sport and exercise is another motivational factor. Female athletes tend to respond well to new methods of coaching and training techniques compared to male athletes (3,5,9,16). It may be thought that the best quality an athlete can have is the ability to be trained, and female athletes are open to trying new techniques if it will help them with their performance and give them the upper hand on their opponents. Consider this: two athletes are training for improvement, athlete A has a "been there, done that" attitude, claims to know the problem and its solution. Athlete B wants feedback: asks what is causing the problem, what can be done, and how to fix it; and takes an approach that analyzes all angles. Athlete B, who is willing to make the effort towards improvement and welcomes criticism seems more desirable than the "know-it-all" athlete A. Female athletes are more likely to be similar to athlete B (3,5).

CONCLUSION

As mentioned in this article, female athletes are intrinsically motivated for other reasons that are compelling to their success as athletes. If you want someone who will show up and not quit, someone who is trainable and motivated all on their own, invest your time in a female athlete.

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THE DEVELOPMENT OF STRENGTH AND CONDITIONING WITHIN DOMESTIC CRICKET IN PAKISTAN—A PERSONAL PERSPECTIVE

MATTHEW TOWLSON, CSCS, AND RICHARD STONIER

INTRODUCTION AND BACKSTORY

For the country of Pakistan, cricket is a passion and a way of life. My name is Richard Stonier and this is my story of how I influenced not only one of the country's up and coming cricket team's approach to fitness and lifestyle, but also that of the wider community. As an English strength and conditioning coach, I was first approached by a former international Pakistani cricketer and now Head Coach the first-class Pakistani cricket team Sui Southern Gas Company (SSGC). This occurred by coincidence when he witnessed my warm-up routine during a semi-professional cricket match in Stoke-on-Trent, England. To the best of my knowledge and according to the club, officials, and national governing bodies, I became the first Western coach to be recruited into a domestic cricket team in Pakistan. This is mainly due to Pakistani coaches being traditionally selected and Pakistan's international cricket team having to train and compete in Dubai, United Arab Emirates ever since the security measures put in place after the 2009 Lahore bombings. Although my recruitment could have been viewed as controversial, the country welcomed me with open arms and there was no obvious backlash from anyone.

SSGC is the largest gas provider in Pakistan and operates four professional sports teams. SSGC cricket team started at the bottom and has progressed through the ranks, developing each year, and recently attracted international superstars. In fact, four of the current squad are part of Pakistan's national team. SSGC has an abundance of talent to work with. As the new Head of Fitness and Development within SSGC, my role was not only to provide the results in sports performance, but also have the players adjust to a different approach to strength and conditioning.

NEEDS ANALYSIS

As part of a needs analysis, the lifestyle and culture of the players must be considered. These were players from a developing nation, with limited resources and infrastructure. They have a strong belief in their religion and know little about Western strength and conditioning and the balance of a healthy lifestyle. Whereas, it is expected to experience delayed onset muscle soreness following an intense training bout, many of these players choose to go to the physiotherapist or doctor, who were often unsure themselves and conservatively suggested that the players rest (2). Therefore, one of the aims of the program was to re-educate and change the players' perceptions.

Despite being some of the most naturally gifted and talented cricket athletes in world, many players were lacking in their physical fitness and had not progressed along with the physical pre-requisites of the sport (10). As with most sports, having the cricket skillset in terms of hand-eye coordination is always key, however, the game has evolved in recent years in that elite cricketers are now stronger, faster, and better conditioned than before. Due to the short length of their training program being 12 weeks and also the limited availability of the some of the international players, strict fitness testing was not warranted. From visual and video analysis of their biomechanics, player feedback, and them not being able to complete a 5-km run during their first initial training sessions, I realized that many of these elite-level athletes were lacking in many different disciplines of physical capacity. I determined that many of them lacked core stability, endurance, and strength, which ultimately hindered their posture and movement patterns, increasing the risk of injury. Only a select few had a reasonable level of physical capacity expected of elite-level athletes.

A cricket match can be a long and tiresome sporting contest, sometimes lasting up to four days. Elite fast bowlers have been reported to cover up to 25 km per day in multiday cricket (5). To ultimately improve the players' performance, they needed to become more well-rounded and durable athletes by being able to consistently field for several hours on any given day in over 100°*F*, and then be able to wake up the next day and repeat it all over again with the appropriate recovery modalities in between. The primary basis for their development was to get them to the point where they would be able to walk off the cricket field at the end of the day with minimal fatigue and to be ready to go again with a smile on their face the following day.

TRAINING PROGRAM

Going back to basics was appropriate for these players, as basic as learning to breathe properly during exercise, to engage through their core musculature and to be aware of their posture. Most days started with 45 – 60 min of field-based strength and conditioning work in the morning followed by 1 – 2 hr of skills-based training, such as batting, bowling, and fielding, and ended in the evening with 30 – 40 min of gym-based work.

The limited training resources available would have potentially been a hindrance to the program had it not been for a bit of improvisation and creativity from myself. Sessions revolved mainly around bodyweight calisthenics with the addition of portable training equipment, such as resistance bands and suspension straps as there was no luxury of a world-class performance facility. Only the players staying at the hotel had access to an old gym with wrought and rusty cast iron lifting equipment, where the gym attendant would tell you off for running too fast on a treadmill during speed intervals. Nevertheless, it allowed the players to train in a gym environment and become more adept at lifting.

Typically, the morning session started with the 5-km run challenge, which was 18 laps of the field. This was not just a physical challenge for the players, but also a mental challenge. On the first day of training, most of the athletes were walking or stopping by the fourth lap. This is where experience in lifestyle coaching proves useful to get the most out of the athletes. The psychology of the players had to be challenged. It was stressed that they would not play for their country based on a performance like that. They were reminded that most people in Pakistan would give anything to be a professional cricketer signed on a 12-month contract in their position rather than having to suffer the hardships of trying to feed a family by other means. The players were left speechless. That was a pivotal moment in their development, and from that moment onwards, the effort level increased.

It is all very well having a structured periodized training program, but how can a strength and conditioning coach get the most out of the athletes for the program to be as effective as possible? Delivering the program by going the extra mile with character, personality, and originality is what makes a strength and conditioning coach stand out. My training philosophy to suit the players of SSGC was to take part in everything and act as a leader, role model, mentor, and friend—someone to look up to every single day. This was critical as many of the players could not speak English, so visual cues to learning were needed to communicate instructions to them successfully. Tiring as it was physically and mentally to participate in over three sessions per day with different groups of people, I believe the players would feed off of and relate well to my enthusiasm and energy.

Given the varying workloads in cricket, the program addressed the phosphagen, glycolytic, and aerobic energy systems (8). The theme of the sessions varied day by day and kept the players on their toes to increase their adherence to the program and minimize the onset of relapse (4). Some days focused on strength or power during cricket-related movements to minimize fatigue due to a decrease in the extent of muscle damage from repeated eccentric contractions, such as the deceleration phase of multiple sprints in cricket (11). Most days focused on specific core work to develop flexibility during dynamic movements used in cricket, such as the delivery stride of bowling (8). This involved pre-activation and pre-habilitation of the lower back, hamstring, hip flexor, and gluteal muscle groups. One player who bowled over 85 mph, showed up to pre-season and moaned of a "niggle" in his groin that had kept him out for seven months even after injection therapy (9). He began a specific core program that targeted the adductor and surrounding muscle groups with both low and high movements to account for his 6'4" frame. Four weeks into his program, he was playing his first competitive match without any pain. This was a key turning point because the other players noticed and became more responsive to the new regimen.

Many players initially opted to rest the day after a match and were not used to training once per day, let alone two or three times per day. One of the challenges was to change these training habits. Within a few weeks of the program, many of the players were actually training at lunch during a match and in the evening after a match. They were starting to buy into the new regimen, as they became mesmerized by their gains in physical capacity and energy levels. They came to realize what their own bodies were capable of doing and described themselves as "Superman." Experiencing this made the players hungry to achieve even more.

In team sports, such as cricket, it is important to train as a collective unit in order to increase cohesion and performance (6). Once the players had been shown correct technique and postural alignment during exercise, one of the key training sessions implemented a few days into the program was a core session, covering multiple disciplines of fitness (Table 1). The team was placed in a circle and each player was chosen to select a core exercise off a board and perform 30 repetitions in the middle of the circle in front of everyone. Facilitating an athlete's autonomous decision-making has been shown to increase performance (7). Until the player in the middle had finished their 30 repetitions, the rest of the team was performing the same exercise. The mutual encouragement from the players brought them closer together.

Eight weeks into their training program, SSGC faced their toughest test yet against the league leaders, Water and Power Development Authority (WAPDA). This was after having already beaten the odds and convincingly eliminated our seemingly stronger local rivals, Sui Northern Gas Company, who were champions for four years running. Surely, it seemed, the odds could not be overcome a second time. The night before the match, I gave the players a motivational speech during a team meeting, using real-life examples of when the underdog team had triumphed over the favorites. It does not always matter who you are or what your background is, but if you have the underlying passion to positively influence a group of people, you can do so. Another string to the bow of a coach is being a motivator. It was stressed to the players that the most talented team on paper does not always win, but rather the better conditioned team with the most heart. It seemed that a spark had ignited within the players that made them feel invincible.

One player stood head and shoulders above the rest against WAPDA for his sheer grit and determination. On day four of a four-day game, a nearly 40 year-old player was up against fatigue and fever. Although his body was giving up, his mental strength to control his actions and his positive mindset resulted in a remarkable individual performance that inspired all of his teammates. He bowled for over four hours and never made an excuse. He just got on with it, which eventually lead to SSGC completing a memorable victory.

The pre- and post-match routines were also designed to be impactful for the players. From the moment the team showed up on the field, the warm-up was more structured than that of the opposition and incorporated elements of pre-activation, dynamic cricket-based movements, and skill-based drills. At the end of the first long and grueling match day against Sui Northern Gas Company, the players who had not been involved requested a training session. While the opposition did not even bother cooling down, the entire squad of SSGC performed a 20-min core workout. Everybody stood and watched in amazement as the players would have normally packed their bags and returned to the hotel. This statement was made to the opposition to make them realize that SSGC was there to compete. It appeared to have worked because SSGC took command of the match the following day.

RECOVERY

With the increased workload of the players, optimal recovery became paramount. The players had only been used to a few minutes of passive stretching at the end of the day and the occasional ice bath, where available. When there were no ice baths available, which occurred often due to the high price of obtaining ice in Pakistan, I improvised by using drum barrels. At the end of each training session, the players were taken through 10 – 15 min of Pilates and yoga-based exercises that not only facilitated their recovery, but also enhanced their range of motion (1). Some of the players used the pool in the evening for active recovery, which also proved convenient for mobility work during rehabilitation. On rest days, players had stopped lying around in bed all day and kept mobile through walking instead.

An important aspect of the recovery process that the players strongly believed in and, therefore, was respectfully included in their program was Hijama. Hijama is performed by Muslims for medicinal purposes and is a form of wet cupping, where blood is drawn by vacuum from small skin incisions.

Additionally, introducing the players to recovery salts and rehydration sachets as a means of maintaining adequate fluid and salt levels was a breakthrough (12). The players described it as the "magic potion," as it reduced their aches and pains. It also provided the players with a rewarding incentive and a placebo-type effect, as I had the cups filled at each break interval, either with or without the salts. Over the course of the entire program, no injuries occurred albeit a few minor niggles, which are to be expected.

TABLE 1. CORE SESSION FOR CRICKET PLAYERS

PLYOMETRIC	PRONE CORE	SUPINE CORE	STRENGTH ENDURANCE	CARDIOVASCULAR
Power lunges	1-min planks	Straight-legged v-sits	Triceps push-ups	Shuttle runs
Power push-ups	Plank hip drops	Unilateral leg extensions	Walking push-ups from standing	Jumping jacks
Ice skaters	Squat thrusts	Reverse pikes	Squat hops	Touch floor jump backs
Tuck jumps		Leg extensions		Burpees
180 switch jumps				
Long jump shuffle backs				

TABLE 2. RECOVERY PROCESS FOR CRICKET PLAYERS

Ice baths
Passive stretching
Yoga and Pilates
Recovery salts
Hijama (wet cupping)
Active recovery (pool and walk)
Adequate nutrition

NUTRITION

Nutrition was one of the most important aspects of the players' lifestyles that needed addressing. Whilst respectful of their cultural differences, one habit that needed changing was the habit of eating curry for breakfast when they were already having curry another 1 – 2 times daily. "Everything in moderation for a balanced lifestyle," was my message to convey to them. In addition to the curry, the players would often have chapati and/or naan bread to mop up the sauce, typically resulting in them feeling bloated. I had to ensure that they started fueling their body for optimal performance with foods that facilitated slow energy release and contain a protein component. The rule put in place was that anyone caught having curry for breakfast would receive a punishment. Although harsh, the punishment would usually be extra laps around the field. Eventually, all of the players were having boiled eggs, porridge, yoghurt, and fruit for breakfast. However, the only fruits easily available in Pakistan were apples, bananas, and pomegranate. It was difficult to provide other colorful fruits that provide antioxidants, such as berries.

The lunch food was initially horrific. During the first lunch interval in Islamabad, I was appalled by the quality of the food: chicken fried in fatty oils and pasta in creamy sauce. Like everything else, it was not going to change overnight. However, the following day presented a few positive changes, such as grilled chicken and fresher pasta with less sauce. I spoke with the hotels we were staying at and the cricket grounds with onsite catering facilities to start providing freshly cooked food for lunch. Eventually, we were able to eat nutrient-dense foods such as chicken, vegetables, mashed potato, and rice to optimally recover from the morning's training and be prepared for the afternoon's training. With each passing day, this process was consistently adhered to more and more. Any leftovers were for grazing or were given to the ground staff living in poverty due to the strong cultural belief of not wasting anything.

CONCLUSION

Everyone, not just the players, were so keen to learn and understand what we (Westerners) do differently than them. The players listened attentively and one of the most crucial elements to their learning was having them realize not just how, but why they were doing what they were doing. Even the manager, who had barely touched on physical exercise, was starting to train in the gym at night because he wanted a better quality of life. Additionally, the support staff, most notably a cancer patient clutching a colostomy bag was walking laps on the field during the break intervals. My role as Head of Fitness and Development covered more than just strength and conditioning, as I was undoubtedly positively impacting individuals' lifestyle and way of thinking. My own philosophy of performance being 70% mental and 30% physical was reiterated to the players every single day. Using a scientific approach to training while taking chances to adapt it successfully to a real-life scenario is a complex skill (3). At the end of the program, a fitness and lifestyle handbook was left for the players to facilitate the retention of the knowledge and skills that they had learned, and to help them live a healthier lifestyle by themselves. With the foundations now in place, my next season of working with SSGC looks promising with the prospect of more fitness equipment and advanced training. Now a force to be reckoned with, the future looks bright for SSGC and Pakistani cricket.

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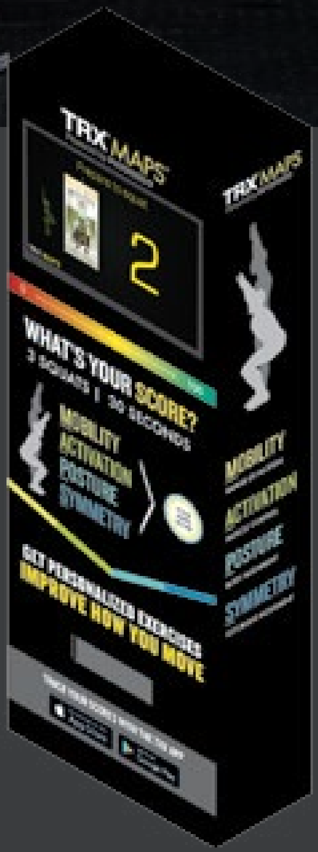

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ECCENTRIC AND MOVEMENT-SPECIFIC TRAINING FOR THE AGING RACQUETBALL PLAYER

RICARDO CAMPOS, BRITTANY CORTINA, AND VERONICA DE LUNA-ALMEIDA

INTRODUCTION

Racquetball was created in 1969 by Bob McInerney (12). It is an indoor racquet sport confined to a rectangular shaped court of 40 ft in length by 20 ft in width. The goal of the game is for the player to win each rally by serving or returning the ball so the opponent is unable to keep the ball in play. Racquetball involves movements across the three anatomical planes: sagittal, transverse, and frontal (5,12,16,18,20). The physical skills needed to play racquetball typically deteriorate with age, but aging adults can still refine their abilities by repeating exercises to perform proper movements during play. A major benefit of training eccentric strength is to aid in the prevention of injuries (4,15). Eccentric strength refers to the amount of force produced when a muscle lengthens as opposed to concentric strength, which is the amount of force produced when a muscle shortens (11). A large portion of players' injuries may be attributable to insufficient eccentric strength in the upper body during the racket's deceleration after serves, groundstrokes, and volleys. Additionally, there may be insufficient eccentric strength in the lower body before the player plants his or her feet during deceleration to establish a stable base for effective stroke production (11). Racquetball-specific training exercises encompass agility and change of direction movements when accelerating and decelerating on the court. Movements of acceleration and deceleration occur repeatedly at a high pace throughout the match. These movements require patterns, distance, and energy systems that focus and resemble competitive racquetball play. These qualities assist in maintaining appropriate body positions to execute the necessary racquetball stroke and then recover for the next stroke (11).

FOCUS AND PURPOSE

This case study article focuses on the male age group from 40 – 75 years old to investigate how improving physical skills can positively influence aging racquetball players' performances. The subject in the figures (Figures 1 – 22) is a 41-year-old male who has been physically active throughout his younger years; however, his ability to perform racquetball techniques on the court have not been satisfactory. He believes his aging has hindered his ability to move efficiently around the court. The purpose of the chosen exercises is to improve agility and change of direction for an aging racquetball player. If training is correctly implemented, the risk of injury can be reduced based on the movement patterns used when changing direction, accelerating, or decelerating (11,16,22).

AGILITY VERSUS CHANGE OF DIRECTION

Agility and change of direction ability are not the same. It is important to define both terms as this will strongly influence the view of each as they relate to racquetball and will also help guide the organization of training in very specific ways. Agility is a rapid whole-body movement with change of velocity or direction in response to a stimulus (9,17). There are two key factors in this definition. First, that changing direction in the context of agility is predicated on the presence of a stimulus. Secondly, based on this stimulus, there is a decision that needs to be made. Every time a player makes a movement towards the oncoming ball, they have perceived the ball, made a decision, and can then execute a movement. Change of direction, on the other hand, is pre-planned and requires skills and abilities to explosively change movement direction or velocities (9). Agility involves a perceptual decision, while change of direction does not. Although change of direction is not agility, agility does require change of direction.

INCORPORATING AGILITY

Agility in racquetball consists of the ability to move on the court and around one's opponent, while being able to react to the ball in a "split second." Agility is described as the skills and abilities needed to change direction, velocity, or mode in response to a stimulus (9). The objectives of agility training involve enhancing power, deceleration, change of direction, and quickness. Power and reactive strength are major qualities that have a significant influence on a player's ability to decelerate (1,11,13). When a player is moving around the court, they must be able to slow down and speed up efficiently to get to the ball. Deceleration is described as a change from higher to lower velocity. Movements of acceleration and deceleration occur repeatedly at a high pace throughout the match. Power for the racquetball player is what directly translates into greater racket head speed and ball velocity (11). In addition, power training engages the nervous and musculoskeletal systems through mobility and balance, overcoming resistance to generate a required force in a shorter amount of time (13,14,19,22). By incorporating jump drills, acceleration training, and deceleration training, a player can develop strength, improve agility, and gain quicker reaction times. These exercises enhance the potential to gain the skills necessary for successful shot-to-ball consistency. Eccentric strength requires training of the muscles during the lengthening phase of the muscle action (11). An example would be during the step before and the loading phase of a forehand stroke. The player's change of direction and deceleration skills will change based on the physiology of aging muscle.

A player's ability to decelerate is a trainable motor skill, and as such, should be included in a well-rounded program. Players who can decelerate quicker in a shorter distance will be faster and have greater body control during the stroke, which will result in a considerable level of dynamic balance and solid ball contact. This can translate to tremendous power for the next stroke (11). Dynamic balance is the ability of the player to maintain a stable center of gravity while the player is moving (3). Altogether, proper deceleration movements help with effective execution throughout the game.

Deceleration drills are intended to improve the aging player's braking ability and assist in the transfer of energy while changing direction on the racquetball court. A drill that can be implemented to work on deceleration is called the lateral deceleration drill. It can be set up as a line drill that focuses on moving from one destination to the next. The player will sprint from point A and try to come to a complete stop before reaching point B (Figures 1 and 2). In lateral deceleration drills, the player rapidly accelerates and then decelerates before a set position, braking while facing perpendicular to the original running direction and actively absorbing the force (19).

Another drill that can be implemented to work on deceleration is the forward deceleration drill. In this drill, the player rapidly accelerates and then, in a fixed number of steps, controls the body into a stopped lunge position (Figure 2). The length can range from 3 – 6 yards, where the goal is to effectively decelerate (9). It is important to transition into a recovery stance that will allow the player to be in position for the next stroke in the rally. The exercise is performed first with just forward running to deceleration and then progressed to forward running followed by lateral deceleration.

FIGURE 1. DECELERATION DRILL – STARTING POSITION

FIGURE 2. DECELERATION DRILL – LUNGE POSITION

While speed and agility rely on a combination of core and lower body strength, quickness refers to the player's body reflexive reactions. Quickness measures the player's instant and rapid responses, and drills to improve these abilities usually only last several seconds (8). The quickness box drill improves quickness in confined spaces, which is the ability to react and change body position (8,9,11). Four cones are set up to create a square with sides measuring 6 – 10 ft long. The cones are numbered 1 – 4. The player is positioned at cone 1 to start and side shuffles to cone 2 (Figure 3). Upon decelerating to cone 2, the player accelerates to cone 3 (Figure 4), then the player will side shuffle to cone 4 before backpedaling to cone 1 (Figure 5). This drill, together with the lateral deceleration drill and forward deceleration drills, is beneficial when the aging racquetball player performs the exercises repeatedly (Figures 3 – 5).

The Z drill develops proficiency in the patterns of side shuffling, accelerating out of a change of direction, and decelerating into a change in direction (22). The Z drill focuses on the player accelerating and decelerating to change direction as the individual reaches the designated cone (Figures 6 – 10). Following a "Z" pattern, the drill consists of a side shuffle, followed by a diagonal sprint, finished off with a side shuffle (9,19).

FIGURE 3. QUICKNESS BOX DRILL – SIDE SHUFFLE

FIGURE 4. QUICKNESS BOX DRILL – ACCELERATION

FIGURE 5. QUICKNESS BOX DRILL – BACKPEDAL

FIGURE 6. Z DRILL – SIDE MOVEMENT

FIGURE 7. Z DRILL – SIDE MOVEMENT

FIGURE 8. Z DRILL – FORWARD MOVEMENT

FIGURE 9. Z DRILL – FORWARD MOVEMENT

FIGURE 10. Z DRILL – ENDING POSITION

To further enhance these movements, an explosive first step would be ideal. Squat jumps (Figures 11 and 12) and box jumps (Figures 13 and 14) can develop a quick explosive first step (1,2,9,14,19). This explosive first step can develop quicker and more powerful directional movements. In doing so, the player gains the ability to exert a lot of force in a short amount of time, as well as increase muscle motor unit recruitment.

Drills like standing side throws strengthen the trunk musculature as well as appendicular structures of the body to enhance dynamic balance and reactive strength (1,2,9,14,19). A plyometric training program that uses lateral and multidirectional movements while limiting time on the ground will develop reactive strength and subsequent power outputs in the muscles and movements that are seen during racquetball play. This type of training directly relates to a racquetball player in one's recovery sequences between shots and also during the times in a point when he or she is "wrong-footed" and is in need of rapid change of direction (11).

Agility training may lessen the amount of time an individual needs to recover. Optimal muscle function is required to generate the forces required in racquetball and to protect against the loads applied to the body as a result of racquetball play. Recovery needs to focus on the upper back, hip abductors, and the muscles of the core (10). The body is better equipped to handle the impact from such movements and can avoid becoming fatigued. The decrease in recovery time allows the player to re-enter the game or match more quickly, as well as return the next day better recovered to perform the activity again at the same level.

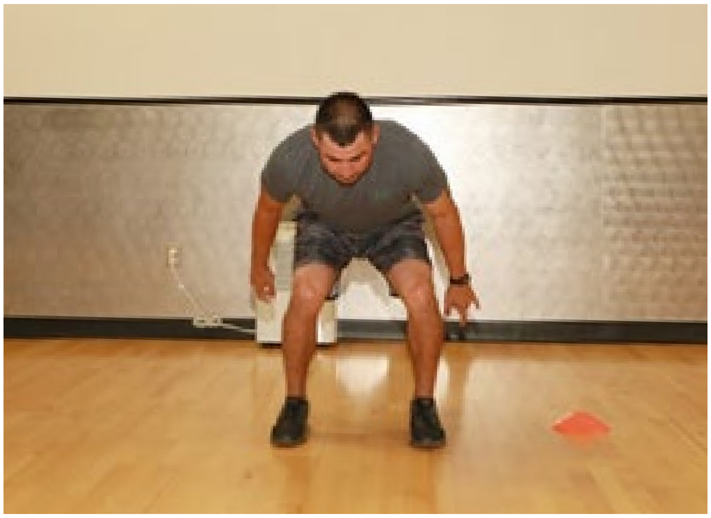

FIGURE 11. SQUAT JUMPS

FIGURE 12. SQUAT JUMPS

FIGURE 13. BOX JUMPS

FIGURE 14. BOX JUMPS

CHANGE OF DIRECTION: ACCELERATION AND DECELERATION

The movements a player performs during a match depend on which direction the ball is hit. Movements of acceleration and deceleration occur repeatedly at a high pace throughout the match. For the racquetball player, these movements transpire in the frontal and sagittal planes of motion, either through lateral or forward/backward movements to reach the ball.

It is essential for the player to move into different positions within a short time in a racquetball game. Change of direction is pre-planned and requires skills and abilities to explosively change movement direction or velocity (9). While practicing directional movements, one must consider dynamic balance, the concept of keeping the body and racquet under control while moving. The key is to keep control of the center of gravity as much as possible during play. The lateral deceleration drill, forward deceleration drill, and Z drill can assist the aging player in enhancing their directional movements. For this purpose, training in all these aspects allow for the aging player to perform movements in a more fluent and painless manner during the game. These abilities and skills are beneficial for good balance and quick reaction speed in forward, lateral, and backward movements. Figures 15 – 20 are additional exercises that specifically target the muscles involved in the various swinging motions used in racquetball.

FIGURE 15. UPWARD SWING WITH 5-LB WEIGHT

FIGURE 16. SIDE MOTION SWING WITH 5-LB WEIGHT

FIGURE 17. UPWARD SIDE MOTION SWING WITH 5-LB WEIGHT

FIGURE 18. BOTTOM SWING WITH 3-LB WEIGHT

FIGURE 19. BOTTOM SIDE SWING WITH 3-LB WEIGHT

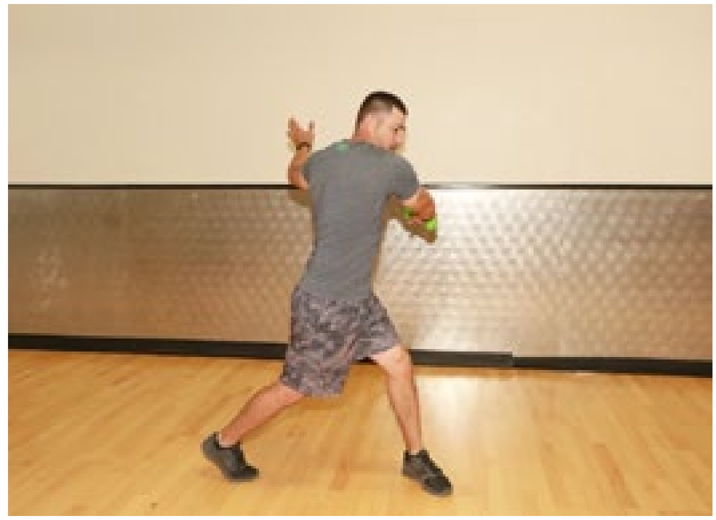

FIGURE 20. BACKHAND SWING WITH 3-LB WEIGHT

CONCLUSION

Racquetball consists of various movements and has different training styles and techniques that target particular skills that can affect an aging player's performance. Racquetball-specific training exercises focus on agility, acceleration, and deceleration, which can help with a player's performance on the court. Deceleration drills, quickness box drills, box jumps, and Z drills require patterns, distances, and energy systems that resemble competitive racquetball play. Practicing quick stops and starts along with hand-eye coordination can help the body work in sync, making movements more fluid for smooth, coordinated transitions while changing direction. Altogether, these drills attempt to strengthen and coordinate the lower extremity muscle groups for the aging racquetball player (21).

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