Understanding how to properly utilize movement pattern continuums is essential knowledge for any personal trainer. Using anecdotal evidence, this article shows the importance and provides examples of how to implement movement pattern continuums into a resistance training program.
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The NSCA Coach publishes basic educational information for Associate and Professional Members of the NSCA specifically focusing on novice strength and conditioning coaches. As a quarterly publication, this journal’s mission is to publish peer-reviewed articles that provide basic, practical information that is research-based and applicable to a wide variety of athlete and training needs.

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When watching a baseball player hit, it is clear that vision is a dominant sensory system. The visual skills of a baseball player go beyond static visual acuity (ability to see clearly in a non-moving position while looking at a non-moving object); hitters must use their vision dynamically. These dynamic visual skills include stereo acuity (depth perception), visual attention, eye movements, dynamic visual acuity (ability to identify objects moving horizontally or vertically at specific velocities), contrast sensitivity (being able to pick a target out of a background), kinetic visual acuity (ability to identify approaching objects at specific velocities), choice reaction time, peripheral vision, recognition time, visual direction, and anticipation (7,9,10,11). Researchers have determined that baseball players have better dynamic visual acuity, stereo acuity, and contrast sensitivity than those who do not play baseball (10,16).

Because most professional baseball players have excellent vision, it is thought that if one could improve a player’s visual skills with sports vision training, one might be able to enhance offensive baseball performance (10). In general, there is an agreement that vision training is beneficial to baseball players, but objective and quantifiable assessment validating the training to enhance baseball performance is relatively lacking in the literature and remains controversial due to research design factors (1,6,8,10,15,16). The purpose of this article is to briefly discuss the relationship between vision scores and training relative to batting performance.

**RELATIONSHIP BETWEEN VISION SCORES AND OFFENSIVE PERFORMANCE**

Four baseball studies have examined the relationship between vision scores and baseball batting performance (4,11,13,14). In 1997, Classe et al. investigated the relationship between vision reaction time (VRT) and batting, fielding, and pitching skill in baseball (4). A vision screening of 213 professional baseball players was performed and the visual reaction times of these players were determined. Official statistics (batting average, fielding average, and earned run average) from the Southern Baseball League were compared to VRT scores. For the 92 players who batted at least 100 times, there was a positive association found between VRT and batting average (BA) (4).

In 2011, Reichow et al. conducted a pilot study that assessed the potential of the tachistoscope, which measures visual recognition time, to determine the ability of 20 collegiate baseball players to identify the type of pitch illustrated in 30 randomly ordered slides showing a pitcher throwing four different baseball pitches (11). For this study, each slide was presented for 0.2 s. The results of the test were compared with the athlete’s BA during the previous season. A positive correlation was found between an athlete’s ability to correctly identify a picture of a pitch presented tachistoscopically and BA. The authors suggested that a superior ability to recognize pitches might relate to a higher skill level in batting.
In 2014, Spaniol et al. reported the relationship between visual skills and batting performance of 352 professional baseball players during the 2013 minor league baseball season (13). Visual skills were assessed using Vizual Edge, which is a computerized software program with a game pad controller designed to assess eye alignment, depth perception, convergence, divergence, visual recognition, and visual tracking. Batting performance was determined by BA, base on balls percentage (BB%), strikeout percentage (SO%), on-base percentage (OB%), slugging percentage (SLG), and on-base plus slugging (OPS). Players were divided into quartiles (groups ranked in 25% categories) based on their comprehensive vision scores. Batting performance was then compared for the upper (top 25%) and lower (bottom 25%) vision quartiles. Statistical analysis indicated significant differences for BA, SO%, OB%, and OPS. When comparing the upper and lower 10% of vision scores, even greater disparities were found for BA, SO%, and SLG. In addition, the upper quartile in BA had significantly better visual recognition response time when compared to the lower quartile. The results of this study provide evidence that superior visual skills are indicative of superior batting performance. The authors suggested that because visual skills appear to play a significant role in batting performance, coaches and trainers should consider using this computerized software program to assess baseball players.

In 2015, Szymanski et al. compared vision performance scores (VPS) before and after 10 weeks of vision training to offensive statistics of nine collegiate baseball hitters with a minimum of 100 at bats (14). Hitters completed vision training three times per week (10 – 15 min per session) for 10 weeks using the Vizual Edge computerized software system. Vision testing and training consisted of vision performance variables, such as vision score, eye alignment, depth perception, visual flexibility, visual recognition, and visual tracking. Pre- and post-training VPS were compared to the offensive statistics of BA, hits, doubles, triples, home runs (HR), runs batted in (RBI), SLG, OB%, base on balls (BB), and strike outs (SO). There was a significant high positive correlation between post-visual recognition and hits, whereas a significant high negative correlation between post-depth perception and SO was found. There were significant positive correlations between post-visual tracking and triples and BB, as well as post-convergence % and BB and OB%. Whereas, significant moderately high negative correlations between post-eye alignment and BB, as well as post-vision score and SO, were found. Collegiate hitters with greater VPS in six of the 11 categories had better offensive statistics. However, those with greater VPS did not have a greater BA or collect more HR or RBI. Therefore, the authors stated that players that have excellent hitting mechanics and possess greater VPS might have the best opportunity to be successful offensively.

**VISION TRAINING AND OFFENSIVE BATTING PERFORMANCE**

Five baseball studies have examined the effects of vision training on batting performance (2,3,5,7,12). In 2005, Bowen and Horth examined the effect of EYEPORT, a vision training system that uses automated colored lights, on the hitting performance of 12 little league baseball players after training 10 min per day, six days per week, for three weeks (2). Before and after the vision training sessions, each player was given a series of 40 curveball pitches fed from a pitching machine at 50 mph. The mean number of successful hits, before and after using the system, was compared. Significant improvement in the total number of hits was demonstrated. The mean number of hits before and after using the EYEPORT vision training system was 17 and 28, respectively. Hits plus foul balls were also evaluated. The mean number of hits plus foul balls before and after training was 24 and 32, respectively, and the players showed a 34% improvement in hits plus foul balls. According to the authors, these results support the premise that the vision training system improved batting performance in little league baseball players. However, since there was no control group that attempted to hit curveballs without vision training, it is not clear as to whether there was simply a learning effect from attempting to hit and see curveballs six times per week for three weeks.

In 2007, Honda et al. examined the effect of bunt training using monocular vision (eye mask covering one eye) on kinetic and dynamic visual acuity and bunt performance in 34 collegiate baseball players (7). The training (fielders) group (n = 27) performed special bunt training using monocular vision three times per week for seven weeks. The pitcher group (n = 7) did not engage in any bunt training. Static, kinetic, and dynamic visual acuity and bunt performance were measured at pre- and post-training. Kinetic visual acuity and bunt performance increased significantly for the training group. However, there was no significant difference of dynamic visual acuity between pre- and post-training in the training group. The pitcher group, as expected, had no improvements. The authors suggested that the training methods utilized in this study improved the kinetic visual acuity and bunting performance; however, the pitcher group did not perform any bunting training whatsoever. If they would have bunted for seven weeks while watching the ball with both eyes, they might have made improvements after practicing. Finally, the authors did caution this form of training because it could be dangerous for children and novice baseball players since one eye was covered while bunting.

In 2008, Spaniol et al. evaluated whether Vizual Edge computerized vision training had an effect on the batting skills of 18 collegiate baseball players that were divided into two equal groups (12). No structured team batting practice took place during the study. Each subject was tested for visual skills to determine eye alignment, eye flexibility, visual recognition, visual memory, and visual tracking. A composite score was also calculated for each subject, which was used to establish personalized vision training protocols. Batting performance was determined by measuring batted ball velocity (BBV) in miles per hour (mph) during two rounds of six swings with balls delivered from a pitching machine. The treatment group received computerized vision training three times per week for five weeks (10 – 15 min per session). Results showed a statistically significant difference between the BBV of the treatment group (52.6 ± 19.6 mph) and
control group (35.1 ± 28.0 mph), indicating that computerized vision training helped produce significantly higher BBV for collegiate baseball players that received vision training. In 2010, Gilliam et al. investigated the effect of Vizual Edge computerized vision training on bat velocity (BV), BBV, and pitch recognition (PR) of 21 collegiate baseball players that were randomly assigned to one of two groups six weeks before the season began (5). The first group (n = 10) was the control group and received no vision training. The second group (n = 11) completed 10 – 20 min vision training sessions over a six-week period consisting of three sessions per week. The vision training consisted of visual flexibility, visual recognition, and visual tracking using the Vizual Edge. Results revealed that the training group significantly improved in convergence percentage, visual recognition response time, visual recognition accuracy, visual tracking response time, and PR. There were no significant differences in BV, BBV, divergence, or depth perception. The data suggests that vision training may improve certain aspects of a baseball player’s vision; however, there was no effect on their BBV, divergence, or depth perception during the pre-season. Although no significant improvements in BBV occurred for either group, the training group significantly improved PR compared to the non-training control group. This may allow a hitter to be more selective in the batter’s box, thus increasing the possibility of being more accurate at bat-ball contact. The authors stated that a limitation of this study was in the measurement of BBV, since the radar gun did not record all batted balls hit within the target zone. It was suggested that future studies count the total number of swings taken to achieve successful BBV data to see if there is a significant difference between groups. This may provide data that demonstrates greater skill in hitting the ball “up the middle.”

In 2012, Clark et al. compared the offensive statistics from a 2010 University of Cincinnati baseball team to the 2011 team before and after vision training (Dynavision, tachistoscope, Brock string, EYEPORT, rotary, strobe glasses, saccades, and near far training) that occurred three times per week for six weeks prior to the 2011 season (3). The college team’s BA increased by 0.034 and their SLG increased by 0.053 in 2011, while the rest of the Big East Conference’s BA and SLG fell over that same time. Essentially, all batting parameters improved by 10% or more. The authors stated that vision training could be implemented in the pre-season and maintained throughout the season to improve batting parameters. Although the authors stated that this was an observational study with no control group, when comparing statistics from year-to-year, a stronger research design would be to evaluate only the players that competed in both seasons and had a specific number of at bats (a minimum of 100).

CONCLUSION

Previous baseball research indicates that better visual skills relate to offensive batting performance, but correlations do not equal a cause and effect relationship (4,11,13,14). Therefore, it is important to evaluate baseball studies that have investigated vision training and offensive batting performance to see if vision training improves offensive statistics. However, research design factors such as no control group, control groups where pitchers did not practice bunting, inappropriate comparisons, multiple types of vision training implemented in one study, and small sample sizes are all limitations that weaken the results and conclusions, indicating the need for further studies on vision training and its effect on offensive performance in baseball. Conversely, improvements in PR and BBV were seen in the two fairly well designed studies conducted by Gilliam and Spaniol, both of which used the Vizual Edge training system.

Hitting a pitched baseball requires many skills; however, a hitter cannot hit what they cannot see. Players at higher levels typically have better visual function and can identify the release point, location, movement, and rotation of the ball better than players at lower levels or non-athletes (8,10,16). It makes sense that improvements to a player’s vision could lead to improvements in their batting performance, but there also needs to be more controlled studies with strong research designs to evaluate performance variables that may not simply be offensive statistics.

REFERENCES


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Development of grip strength is often overlooked in traditional resistance training programs. This underdevelopment can manifest itself as a weak link in the kinetic chain involved in many field, combat, and rotational sports. Rightfully, a priority of any program's goals should be to maximize the strength and power within major motor patterns associated with the performance and needs analysis of the given sport (5,6). Those qualities have a greater impact on overall athletic ability and should be developed continually as part of a long-term athletic development plan. Additionally, making small alterations to traditional movements and supplementing a periodized resistance training program with grip-specific movements may benefit athletes in a variety of ways. Typically, grip-specific training can be performed directly using specialized equipment. While effective, these tools can be expensive for coaches at the high school and small college level, and be non-functional for group training environments. Instead, using training methods that can improve grip strength indirectly while facilitating the development of the program’s primary goals may be most desirable.

Grip strengthening may be a secondary or tertiary goal in the annual development plan for athletes, but its training can be done with little expense or needs for special equipment. Small program adjustments that target grip strength and improve its function can be implemented without large sacrifices to time or resources. The methods and protocols provided in this article will demonstrate low cost methods of improving grip strength for various sport performance needs.

GRIP STRENGTH AS A PERFORMANCE VARIABLE

Often seen in sports with a demand for rotational power (e.g., golf, baseball, and tennis), athletes use force generated from the lower body and transfer that force into the distal segments of the hand and fingers via what practitioners label as the “kinetic chain.” Force is produced from the legs and hips into the ground, transferred through the torso, and makes its way into the hands and implement. Efficient sequencing of these movements leads to faster angular velocities of the distal segments, which is typically the hands. While the actual contribution of force from the muscles of the hands and forearms are negligible, the transfer of force is a valuable factor. The muscles of the forearms, hands, and fingers are tasked with the final transfer of power through the kinetic sequencing of rotational movements. Development of functional grip qualities may provide an advantage in various sports relying on the hands and forearms as the last link in the kinetic chain. This principle is demonstrated in implement-based sports, where an increase in grip firmness reduces impact recoil and improves the exit-velocity of the intended target (4). The stronger the grip on the implement, the less distraction occurs during contact with the intended target. Less distraction upon contact allows for greater energy conservation, which is of high value to athletes involved in
sports where imparting high exit-velocities on a target is beneficial. This is especially significant when it comes to off-center impacts where the distractive forces are often at their greatest.

Within combat and sports that intrinsically have high levels of physical contact, grip strength can be an important factor for subduing or controlling an opponent. Wrestlers, judokas, and grappling athletes have a specific need for high levels of both grip strength and endurance (1,7). Increasing the functional strength of the hands and forearms in specific positions is beneficial to improving an athlete’s ability to manipulate their environment, objects, or opponents.

**Grip Strength Training Considerations**

The muscles of the flexors in the hand and forearm create gripping force, while the extensors of the forearm stabilize the wrist (13). Exercises aimed at improving grip strength should stress the flexors to improve the amount of force produced in gripping actions, while the extensors of the forearm should also be trained to improve the endurance and stability of the hands and wrist against an external load. In grip training, there are three main grip holds: crushing (finger to palm), pinching (finger to thumb), and supporting (carrying a load for distance or time). Implementing movements that help stress each distinct variation promotes specific grip strength adaptations. Maximal strength or muscular endurance can be developed using these varied movements (12). Specific training implements can be costly, and are often designed for individual use rather than a team training environment. Therefore, the strength and conditioning professional should consider methods that are easy to use and can be modified for different training ages. One of the most efficient ways to enhance grip strength is through simple manipulation of pre-existing training implements like dumbbells, barbells, and pull-up bars.

**Methods to Develop Crushing Grip**

Gripping larger diameter objects with a crushing grip requires higher muscular force (compared to gripping smaller objects) (3). Wrapping a hand towel around a barbell or dumbbell increases the circumference of the gripping surface and alters the stability between the hand and the implement (Figures 1 – 6). Using towels allows athletes to train with movements they are accustomed to without making significant alterations to program design or purchasing expensive training tools.

An unstable load requires advanced levels of stabilizing strength from the hands as well as the forearms (12). This requires an athlete to apply greater than normal squeezing force with the hand and forearm to complete the desired action and recruits the forearm extensors to stabilize the wrist. Hanging a towel or pair of towels from a pull-up bar mimics normal pull-ups, but adds the challenge of an unstable gripping surface (Figures 7 – 10). Similar methods can be implemented to the bent-over row (Figures 5 and 6) and the inverted row (Figures 11 – 12). By resisting gravity and bodyweight, towel pull-ups stress the flexor muscles of the forearm, hand, and fingers while simultaneously stressing the stabilizing muscles of the wrist. Likewise, using a towel through the handle of a kettlebell increases the diameter and instability of movements like the kettlebell swing (Figures 13 and 14). Figures 1 – 16 demonstrate different exercise modifications that can be made using a towel on a standard bar, dumbbell, kettlebell, and pull-up bar.

**Plate Pinching and Plate Flips**

Pinching strength is the application of force from the fingers to the thumb. The functional abilities of this hand position can be utilized in “precision-handling” tasks and should be considered in the strength programs for athletes who need to develop more finely-tuned grip strength qualities of the hands and fingers (e.g., baseball pitchers, cricket bowlers, rock climbers, etc.) (8). Forceful pinching involves greater stress on the tendons of the forearm than a crushing grip position (3). Weighted pinching is a simple and effective method of improving the strength of the fingers utilized in the pinching grip (Figures 17 – 20). Pinching two plates of equal weight together for an established amount of time is an exercise that can be easily implemented in most weight rooms. Pinches can be done with one or two hands. Isolating specific fingers or groupings of fingers can allow for more specificity within the resistance training program depending on the needs of the athlete or the demands of the sport.

Performing plate flips with bumper plates is a dynamic movement that is specific to pinching grip strength (Figure 21 – 23). Plate flips can be performed with two hands as well (Figures 24 – 26), which allows for variation while training for sport specificity. Adding more plates to pinching holds, using heavier plates for pinches and flips, or using more challenging grip positions are ways to develop pinch grip strength and endurance progressively. Figures 17 – 26 demonstrate different varieties of pinch holds that can be done using weighted plates.

**Weighted Carries**

Holding heavy loads while moving is a way to develop strength for the supporting grip position. Additionally, weighted carries replicate real-life challenges involved in daily living, are a known training method used by strongperson athletes to develop grip strength and core strength, and have been used to measure anaerobic capacity (14,15,16). While often performed with special equipment, farmer’s walks can be performed with common dumbbells (Figures 27 – 28). Depending on the needs of the sport, an athlete may require many different hand and wrist positions that should be specifically trained to have maximum transfer to their sport or activity (11). Carrying exercises that train isometric holding strength and endurance are specifically beneficial to combat sports, where grip may play a key role (1,7). Using a variety of implements for different weighted carries can keep athletes engaged in new challenges while promoting strength through different grips.

Grasping dumbbells from a single end can challenge the supporting and gripping strength of the entire hand (Figure 29). Although the brand and type of dumbbell available limit training adaptations, grasping a single end of one or two dumbbells and
walking for time or distance (in a similar manner as a farmer’s walk) can improve grip strength. Using kettlebells is another method to increase variety, especially by implementing them with unilateral carries, bottoms-up carries, or using the lateral side of the kettlebell handle to increase the stability demand at the wrist (Figures 30 – 31). Using unilateral carries has the added benefit of challenging the stability of the spine and developing strength of the back or core (Figures 31 – 32) (9). Figures 27 – 32 demonstrate varieties of weighted carries using common implements.

**PRACTICAL CONSIDERATIONS**

Table 1 provides an example of grip strength training modifications that can be easily implemented into a training program. Supplementing a training program with grip-specific movements after the majority of strength training is completed can be useful to specifically improving grip strength, while having the added benefit of improving performance on other movements where grip strength is a limiting factor. Drop sets can be used to simultaneously train for strength and power and grip strength. This method allows for progressive overload, while benefitting grip strength. Adding two sets of a grip-specific exercise can keep the training program efficient and volume manageable.

Plate pinches, towel farmer’s walks, towel dumbbell carries, and towel kettlebell swings are best suited for the latter parts of a training session. Targeting grip strength early in a training session fatigues the muscles of the forearms and hands, which can be detrimental to performance on greater priority lifts. Using these exercises as part of an anaerobic capacity circuit allows for variation of muscle use across a range of grips. This allows multiple training goals to be developed without spending an unnecessary amount of time performing isolated training of the wrist and forearm.

**CONCLUSION**

Improving grip strength is not a primary goal in many strength and conditioning programs, though its inclusion can improve athletic performance. For athletes participating in rotational power sports, increasing grip strength on an implement can improve energy transfer. Considerations for developing grip strength and endurance are especially important for combat sport athletes and can be implemented as a part of their metabolic conditioning program, implementing specific grip-focused training exercises can have a positive impact on grip strength and endurance.

**REFERENCES**

ABOUT THE AUTHOR

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TABLE 1. EXAMPLE GRIP STRENGTH TRAINING MODIFICATIONS

<table>
<thead>
<tr>
<th>TRAINING SESSION</th>
<th>COMPOUND MOVEMENT FOR STRENGTH DEVELOPMENT (75 – 85% 1RM)</th>
<th>SETS X REPS</th>
<th>MODIFIED DROP SET FOR GRIP STRENGTH FOCUS (45 – 55% 1RM)</th>
<th>SETS X REPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Barbell bent-over rows</td>
<td>3 x 5</td>
<td>Towel barbell bent-over rows</td>
<td>2 x 12</td>
</tr>
<tr>
<td>2</td>
<td>Pull-ups</td>
<td>3 x 10 – 12</td>
<td>Towel pull-ups</td>
<td>2 x 5</td>
</tr>
<tr>
<td>3</td>
<td>Single-arm dumbbell bent-over rows</td>
<td>3 x 5 each</td>
<td>Towel single-arm dumbbell bent-over rows</td>
<td>2 x 8 – 12 each</td>
</tr>
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TABLE 2. EXAMPLE CIRCUIT

<table>
<thead>
<tr>
<th>EXERCISE</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jump rope</td>
<td>60 s</td>
</tr>
<tr>
<td>Farmer’s walks</td>
<td>30 s</td>
</tr>
<tr>
<td>Push-ups</td>
<td>60 s</td>
</tr>
<tr>
<td>Plate pinches</td>
<td>30 s</td>
</tr>
<tr>
<td>Towel kettlebell swings</td>
<td>60 s</td>
</tr>
</tbody>
</table>
EFFECTIVE METHODS OF GRIP STRENGTH DEVELOPMENT

FIGURE 1. TOWEL BARBELL BENT-OVER ROW

FIGURE 2. TOWEL BARBELL BENT-OVER ROW

FIGURE 3. TOWEL ON A DUMBBELL

FIGURE 4. TOWEL ON A DUMBBELL

FIGURE 5. TOWEL SINGLE-ARM BENT-OVER ROW

FIGURE 6. TOWEL SINGLE-ARM BENT-OVER ROW
FIGURE 7. TOWEL PULL-UP

FIGURE 8. TOWEL PULL-UP

FIGURE 9. TOWEL PULL-UP

FIGURE 10. TOWEL PULL-UP

FIGURE 11. TOWEL INVERTED ROW

FIGURE 12. TOWEL INVERTED ROW
EFFECTIVE METHODS OF GRIP STRENGTH DEVELOPMENT

FIGURE 13. TOWEL KETTLEBELL SWING

FIGURE 14. TOWEL KETTLEBELL SWING

FIGURE 15. TOWEL KETTLEBELL FRONT RAISE

FIGURE 16. TOWEL KETTLEBELL FRONT RAISE

FIGURE 17. WEIGHTED PINCHING

FIGURE 18. WEIGHTED PINCHING
FIGURE 19. WEIGHTED PINCHING

FIGURE 20. WEIGHTED PINCHING - TWO HANDS

FIGURE 21. SINGLE-ARM PLATE FLIP

FIGURE 22. SINGLE-ARM PLATE FLIP

FIGURE 23. SINGLE-ARM PLATE FLIP
EFFECTIVE METHODS OF GRIP STRENGTH DEVELOPMENT

FIGURE 24. TWO-ARM PLATE FLIP

FIGURE 25. TWO-ARM PLATE FLIP

FIGURE 26. TWO-ARM PLATE FLIP

FIGURE 27. FARMER’S WALK

FIGURE 28. FARMER’S WALK
FIGURE 29. GRIP VARIATION

FIGURE 30. KETTLEBELL SINGLE-ARM FARMER’S WALK

FIGURE 31. KETTLEBELL SINGLE-ARM FARMER’S WALK

FIGURE 32. KETTLEBELL SINGLE-ARM UNILATERAL CARRY

FIGURE 32. KETTLEBELL SINGLE-ARM UNILATERAL CARRY
A n important thing for a strength and conditioning coach who is working with youth athletes to remember is that youth like to have fun. Also, the earlier youth begin to be active and develop motor skill competence and muscle strength, the more likely they will be to continue being physically active later in life. Having youth engage in physical games that support physical literacy and long-term athletic development can be a great way to keep them excited and active with physical activity.

GAMES
Just about everyone can remember having a lot of fun playing games when they were young. Whether it was organized games like kickball, tag, and red light, or made-up games, most kids were active, used a variety of movement patterns, trained all fitness attributes (without knowing it), and had fun doing so. With the adult-driven, specialization-focused world of youth sports, these games are becoming less common in today’s age.

According to Halford, coaches should note the differences between drills and games when progressing young athletes from learning skills to teaching technique in more advanced game-like activities (5). Table 1 provides basic guidelines to help differentiate between drills and games.

PROGRAMMING GAMES
THE EARLIER THE BETTER
The earlier youth are provided with positive exercise experiences, the greater their chances will be to develop motor skill competence, fitness (especially muscle strength), and athleticism (9,10). According to the NSCA Position Statement on Youth Resistance Training, youth can start a properly designed and supervised resistance training program at approximately eight years old (3). The position statement also highlights that kids need age-appropriate training, which includes varying exercises and activities and adding fun games.

COMPOSITE YOUTH DEVELOPMENT MODEL
The Composite Youth Development Model encourages youth to train all fitness attributes (health-fitness and skills-fitness) (7). Since fitness attributes are trainable across childhood and adolescence, it is important to include games that address all fitness attributes over time. Games can be beneficial because they incorporate many fitness variables and often utilize various motor skills. Since games can be physically demanding, they should be programmed correctly within the program design to prevent overuse and overtraining. One way to minimize the risk of overtraining is to systematically program exercises, games, and motor skill activities using the Composite Youth Development Model, which provides an excellent reference point from which to begin programming (7). In the Journal of Strength and Conditioning Research, Lloyd et al. provides tables for the Composite Youth Development Model for males and females that demonstrate how existing models of youth physical development and talent development can be merged (7). Strength and conditioning coaches can use this model as a basic guideline to help develop a specifically tailored strength and conditioning program for each individual youth athlete.

TRAINING AGE
The next consideration is training age, which is the amount of years of experience performing a regular workout routine. Training age is typically applied to resistance training but can be thought of in the context of any skill or activity (2). Games must be taught properly and with a sequence in mind. For younger children who are just learning movement skills, time must be spent teaching the skills before applying them in a game setting. For adolescents who are going through “adolescent awkwardness” or have never been taught fundamental movement skills, remedial exercises with movement skill mechanics may be necessary. For youth with movement skill mastery, progressions of games that are more challenging can be provided to keep them engaged in the games and activities.

CLASSIFICATION OF GAMES
Just as coaches have classifications of motor skills (e.g., body awareness, locomotor, and object control), fitness attributes (e.g., health-fitness and skills-fitness), and sport skills (e.g., open or closed, simple or complex), there are classifications of games as well (e.g., tactical or developmental) (4,6,7,11).

Tactical games can be further broken down into invasion, net and wall, striking and fielding, and target games. To fully develop physical literacy, which has been described as the “ability, confidence, and desire to be physically active for life [for all young athletes as part of a long-term developmental process],” games should be purposefully selected from all categories (1). As youth choose the sport in which they wish to dedicate their efforts, typically around age 15, specialized games that reinforce the demands and strategies of the chosen sport are appropriate (8). Even with specialized games, it is important to remember to balance movement in all three planes of motion and use all fitness attributes for complete development.

Developmental games can be further broken down into pursuit and evade, cooperation, foundational movement, and theme games (theme games do not necessarily fit into any category but are a fun way to build team unity). Again, a variety of developmental games along with fitness attributes and sport skills can help to build the foundation for physical literacy and long-term athletic development. A systematic approach based on developmental appropriateness is essential.

CONCLUSION
Youth like to have fun; utilizing games can be a great way to let them have fun while simultaneously developing skill acquisition and mastery. Properly planned games can support physical literacy and long-term athlete development. It can also help to keep youth engaged while providing training of all fitness attributes,
motor skills, and sports skills. Strength and conditioning coaches who systematically progress specific training variables, including games, can help youth improve performance and reduce the risk of injury.

REFERENCES


TABLE 1. DRILLS VERSUS GAMES (5)

<table>
<thead>
<tr>
<th>DRILLS</th>
<th>GAMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Lines</td>
<td>Free movement</td>
</tr>
<tr>
<td>Regimented</td>
<td>Unstructured</td>
</tr>
<tr>
<td>No decision making</td>
<td>Decision making</td>
</tr>
<tr>
<td>Boring</td>
<td>Fun</td>
</tr>
</tbody>
</table>

ABOUT THE AUTHOR

Rick Howard helped start the National Strength and Conditioning Association (NSCA) Youth Special Interest Group (SIG) and served this year as Immediate Past Chair. In addition, Howard serves on the NSCA Membership Committee and is the NSCA State/Provincial Program Regional Coordinator for the Mid-Atlantic Region. Howard is involved in many pursuits that advance knowledge, skills, and coaching education to help all children enjoy lifelong physical activity and sports participation.
It is well known that all rotational movements occur in the transverse plane and are a necessary component to athletic and everyday movement. Without rotational movement, trying to throw a baseball, swing a golf club, or kick a soccer ball would be just about impossible.

Almost every strength and conditioning professional has had some level of exposure to suspension bodyweight training. Some swear by it, others can take it or leave it. The utilization of suspending bodyweight for training purposes has found its way into many health clubs, fitness facilities, and collegiate/professional performance facilities in some capacity. So, what is rotational suspension bodyweight training and how is it different from traditional suspension bodyweight training?

The key difference between traditional suspension bodyweight training and rotational suspension bodyweight training primarily lies in the anchor point of the equipment. Rotational suspension bodyweight training typically uses a locking/unlocking pulley system, which allows the user to add greater instability and rotational movement to traditional suspension bodyweight training exercises. Most suspension training devices have a locked or static anchor point and are affixed by a single anchor point or double attachment point, meaning the strap length can be changed but not during a movement. Thus, the range of motion one can perform during an exercise movement (e.g., the body must move around a handle or ring) is limited. On the other hand, rotational suspension bodyweight training typically involves using equipment that has the option of having the anchor point locked or unlocked. When locked, the device is virtually the same for stability and range of motion found with traditional suspension training units. However, when the anchor is unlocked, these devices can add greater range of motion, rotation, instability, and the ability to add dynamic tension to traditional suspension bodyweight training movements.

Consider the following ways a free moving anchor point changes traditional suspension bodyweight training and provides greater rotation:

- **Increased core engagement:** Suspension bodyweight training has been shown to increase core engagement (1). However, most of the engagement is distributed in the sagittal plane due to the limited range of motion of the handles in traditional suspension training movements.

- **Increase in rotational stability/instability:** A centralized rotating anchor allows for rotational movements while performing suspension bodyweight exercises. This allows the body to rotate around its center of gravity naturally.

- **Dynamic tension:** Introducing rotation allows the user to apply their own muscle resistance on the eccentric movement.
ROTATIONAL TRAINING UTILIZING SANDBAGS
While medicine balls have also become commonplace for weighted rotary movements within most training facilities (e.g., wood chops, slams, tosses, etc.), sandbags can provide a different stimulus from medicine balls and other weighted rotational training tools.

Sandbag training can be used in virtually all fashions and exercises that mimic or replicate traditional medicine ball training. However, the sandbag offers some additional dimensions that cannot be trained with medicine ball exercises, such as dropping, throwing, and rotational exercises where the athlete does not have to account for the sandbag rebounding or bouncing back. Furthermore, grip strength, increased load (medicine balls typically do not weigh more than 30 lb, whereas sandbags can weigh in excess of 200 lb), and controlled eccentric loads are more prominent than medicine balls. Utilizing sandbags can be an important asset to performing speed and power exercises.

While the primary focus of functional training is to help adjacent muscle groups work together, rotational strength development also requires that synergistic muscle groups work in unison to effectively and dynamically stabilize the lumbar spine during any sort of transverse or rotational movements. Rotational training does not have be explosive to train the muscles responsible for transverse movements. Training the muscles of the spine and core may help in preventing excessive rotation of the spine, specifically the lumbar spine, which can lead to injury.

Structurally speaking, the lumbar spine is designed to prevent or limit the amount of rotation that occurs (2). The lumbar spine typically allows for 10 – 15 degrees of rotation for most healthy individuals, while the thoracic spine provides 60 – 70 degree of rotation (2). In other words, the thoracic spine, not the lumbar spine, should be the site of the greatest amount of rotation (2). Understanding these movement parameters can act as a foundation for better understanding how to design a safe and truly functional rotational movement program.

ROTATIONAL TRAINING EXERCISES
Figures 1 – 12 demonstrate several exercises specifically designed to increase range of motion, flexibility, rotational strength, and dynamic stabilization utilizing rotational suspension bodyweight training and sandbags.
SINGLE-ARM ROW WITH DYNAMIC TENSION (FIGURES 3 AND 4)
Begin by facing towards the unlocked anchor with the feet in a staggered stance. Grasp both handles in a position similar to an inverted row. Engage the lumbar spine and core, pulling with the hand opposite of the forward foot. Pull the hand towards the chest while rotating at the thoracic spine. Apply tension with the eccentrically loaded forward hand throughout the movement. Return to the starting position and repeat the movement with the other side.

ANTI-ROTATIONAL TWIST WITH PRESS (FIGURES 5 AND 6)
Begin by attaching a weight (e.g., kettlebell, dumbbell, sandbag, plate, etc.) to one end of a cable or pulley. Stand next to the unit and assume an athletic position. Grasp the handle with both hands to the side of the body. Keeping the arms straight, bring the handle to the middle of the body. Then, bring the hands to the chest in a pressing motion. Press back out to return to the starting position and repeat the movement.
HURDLE STEP WITH REACH AND PULL (FIGURES 7 AND 8)
Begin by facing towards the unlocked anchor. Grasp both handles and assume a lunge position. In the lunge position, the arm on the same side as the lead leg will be extended while the opposite hand is pulled back. From this position, drive the knee of the back leg forward while pulling the extended hand back. Apply dynamic tension on the pulling motion. Return to the starting position and repeat the movement on the other side.

REVERSE PULL AND FORWARD PUSH WITH ROTATION (FIGURES 9 AND 10)
Begin by attaching the unlocked anchor of the device to a sled or sandbag. Facing the unit, grasp both handles and step away from the sled or sandbag until there is no slack in the rope. From a partial squat position, step back and pull the handle to one side of the body, as if performing a single-arm row. Take a step back and perform the row on the opposite side. Repeat the movement in an alternating pattern.

Instead of pulling while moving backwards, this can be reversed to push while moving forward. To perform this, follow the same steps except face away from the sled or sandbag, lunge forward, and start each press from shoulder level and move the hand up in a diagonal direction.
TAKE ROTATIONAL TRAINING TO THE NEXT LEVEL

SANDBAG ROTATIONAL TOSS (FIGURES 11 AND 12)
Stand with the feet parallel and assume an athletic position with the back neutral, knees bent, and core engaged. Hold the sandbag with the inside handles and rotate the bag toward the outside of the hip while maintaining good posture and loading through the same hip. Accelerate toward the opposite side and transfer the weight from the trail leg to the front leg. Rotate through the movement and release the sandbag at the end of the motion, including a long follow-through with the arms. This exercise should be performed explosively and can be done at any desired angle or release point that best fits the need of sport or athlete. Perform the desired amount of repetitions on each side or perform in an alternating pattern.

CONCLUSION
The purpose of any rotational training program should be to increase the engagement of the stabilizing muscles of the lumbar spine (rotators and anti-rotators) as well as increasing the strength and range of motion of the thoracic spine. Training in multiple planes may improve the ability to stabilize dynamically and help in reducing injuries while increasing physical performance.

REFERENCES

ABOUT THE AUTHOR
Chris Camacho has been involved in the sports and fitness industry for more than 20 years. He currently serves as Director of Education and Programming at CrossCore®. Prior to joining CrossCore, he served as the Director of Fitness Development and Programming for GoFit, Director of Strategic Partnerships for Fitness Anywhere (TRX), Director of Business Development and Sports Marketing for Power Plate North America, and has worked with numerous professional strength and conditioning coaches and programs domestically and internationally throughout his career. Camacho earned his Master’s degree from the University of San Francisco in Sport Management and his Bachelor’s degree in Exercise Physiology with an emphasis in Athletic Training.

Joel Raether has served as the Head of Sport Performance for the Colorado Mammoth Lacrosse team of the National Lacrosse League (NLL) since 2007. He served as the Education Program Coordinator for the National Strength and Conditioning Association (NSCA) from 2009 – 2011. His coaching career includes stints as the Assistant Strength and Conditioning Coach for the University of Denver from 2002 – 2009 and the University of Nebraska at Kearney from 2000 – 2002. Raether earned his Bachelor’s and Master’s degrees in Exercise Science from the University of Nebraska at Kearney and is a Certified Strength and Conditioning Specialist® with Distinction (CSCS, “D”) through the NSCA. Raether has co-authored the books 101 Agility Drills, 101 Sandbag Exercises, and was also a contributing author for Fit Kids for Life, Developing Agility and Quickness, and Core Training for Sport.
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CONSIDERATIONS FOR REPORTING RESISTANCE TRAINING PROGRAM DESIGN

JONATHAN ANNING, PHD, CSCS,*D

A strength and conditioning coach has many responsibilities when designing a resistance training program. A textbook generalization of the responsibilities includes the following steps: needs analysis, exercise selection, training frequency, exercise order, training intensity, training volume, and recovery considerations (2). Unfortunately, many components of these responsibilities are reported in research controlled environments (e.g., laboratory settings) or anecdotally as successful outcomes (e.g., training associated with championship achievement). In this article, I provide some strategies that a strength and conditioning coach can use to bridge the gap between research and anecdotal experiences by reporting subjective and objective information obtained while carrying out everyday responsibilities. These strategies will include the seven common steps for program design that should be used a framework to bridge the gap between research and practice.

CONFIDENTIALITY CONSIDERATIONS
Before examining the framework, it is important to highlight considerations related to reporting data. Although anecdotal experiences tend to be subjective information associated with a team, objective data from screenings, analyses, assessments, and outcomes has the potential to be individualized. Specifically, when reporting data, an individual should never be identified relative to health conditions or performance capabilities. To avoid this concern, reporting data can be done by using descriptive statistics (e.g., averages and ranges). Keep in mind that any institutional review board can clarify concerns related to reporting data in an article, presentation, or other method of dissemination.

STEP 1: NEEDS ANALYSIS
The needs analysis involves evaluating the dynamics of the sport and assessing the athlete’s capabilities. An assessment of the athlete begins with a medical history and training status considerations followed by fitness testing and goal setting. These assessments can be reported based on individualized events, sport positions, or other athletic comparisons that facilitate profiling an individual’s injury concerns as well as skill potential. Coinciding evaluations of the sport’s common injuries and dynamic demands will further assist with the needs analysis process. Whether the athletic trainer reports specific injuries associated with a sport, position, or event, or the strength and conditioning coach identifies common movements and physical requirements, a collaborative effort accomplishes the best scenario for athletic success.

STEP 2: EXERCISE SELECTION
Once athletes are properly evaluated for success, appropriate exercises may be prescribed to maximize training potential. In conjunction with the large variety of exercises to select, considerations involve individual athlete’s health and performance capabilities along with the sport’s event, position, or season...
demands. In other words, reporting exercise selection successes and failures based on an athlete’s background, capabilities, previous injuries, sport position, as well as the sport’s program periodization schedules may help in allowing training goals to be achieved safely and effectively.

STEP 3: TRAINING FREQUENCY
Creating a weekly schedule integrates the selected exercises by establishing a training frequency based on an athlete’s training status and the sport’s season. The resistance training frequency is less for beginners and in-season training, whereas a greater frequency emphasis occurs during the off-season and with intermediate to advanced training levels. If the resistance training sessions exceed three days per week, a split routine can be utilized to prevent overtraining. Every strength and conditioning coach has the option to use this textbook approach. Regardless of whether they follow or deviate from these guidelines, they should report how their training frequency methods influence event and team performances.

STEP 4: EXERCISE ORDER
After determining training frequency, two possible split routine choices can be used to structure the exercise order for each session (an upper-lower body or a push-pull approach). Resistance training for three sessions per week or less permits both exercise order options. For maximal repetition efforts, the order progresses from explosive exercises to slow and controlled multi-joint and single-joint exercises. Furthermore, compound or super sets may be used to overcome training adaptation plateaus. Again, these are textbook recommendations that may be followed, but exercise order variations do occur. Order influences exercise, event, and team performance, which is why reporting outcomes can help develop maximal exertion strategies without hindering muscle capabilities.

STEP 5: TRAINING INTENSITY
Training intensity is based on knowing the one repetition maximum (1RM) when performing an exercise to exhaustion, yet light and moderate days are necessary to avoid overtraining. Reporting prescribed intensities when adjusted throughout periodization cycles enables the strength and conditioning coach to effectively assess athletes’ progress in order to achieve competitive peaks at the appropriate times (1).

STEP 6: TRAINING VOLUME
There is an inverse relationship between training intensity and volume (1). This relationship should be monitored to identify any diminishing returns. For instance, it is expected that training volume will decrease as the off-season progresses toward the in-season. The training volume is the total amount of repetitions completed. When a maximal or submaximal effort is given, the load volume and repetition volume can be reported to discover how the manipulation of sets affects periodization cycle performance.

STEP 7: RECOVERY CONSIDERATIONS
Out of the seven steps of designing a proper resistance training program, rest periods are often the most overlooked, despite being a necessity. In order to monitor performance and fatigue, measuring changes in performance or surveying athletes’ perceptions is essential. An athlete’s perceptions can be surveyed between exercises, sets, and training sessions. It is much more difficult to identify overtraining through an athlete’s perception, but customized surveys can assist with this process. Overall, analyzing and reporting relationships between an athlete’s perception and performance can facilitate establishing benefits and risks of different training programs and outcomes.

CONCLUSION
Reporting findings relative to program design findings for resistance training and performance outcomes (e.g., exercise strength, injury analyses, position capabilities, event results, season achievements, athlete perceptions, etc.) can be beneficial to any athlete. Table 1 provides reporting examples and considerations for each step. Successes and failures should be reported to better understand what to incorporate and avoid when designing a resistance training program to achieve performance outcomes. A combination of scientific resources, such as textbooks and research, along with the personal knowledge of anecdotal experiences can bridge the gap between academia and practitioners regarding designing safe and effective resistance training programs (1,2). Publishing articles in NSCA Coach provides an opportunity for collaboration between researchers and strength and conditioning professionals by exchanging knowledge on resistance training strategies.
## CONSIDERATIONS FOR REPORTING RESISTANCE TRAINING PROGRAM DESIGN

### REFERENCES


### ABOUT THE AUTHOR

Jonathan Anning is an Associate Professor of Exercise Science in the Exercise and Rehabilitative Sciences Department of Slippery Rock University of Pennsylvania. His specialization is strength and conditioning, and he has been teaching at the college level since 1993. His primary research interests focus on sports performance with an emphasis on assessments and resistance training techniques. His professional strength and conditioning experience includes college football and minor league baseball. He has degrees in Exercise Science from Central Michigan University and the University of Toledo. He has been a Member of the National Strength and Conditioning Association (NSCA) since 1994, and maintains the Certified Strength and Conditioning Specialist® with Distinction (CSCS,*D®) certification.

### TABLE 1. SUMMARY OF REPORTING EXAMPLES AND CONSIDERATIONS

<table>
<thead>
<tr>
<th>STEP</th>
<th>EXAMPLES AND CONSIDERATIONS</th>
</tr>
</thead>
</table>
| **Step 1:** Needs Analysis | Athletic trainer: Common sport, position, or event injuries  
Strength and conditioning coach: Common movements of sport, position, or event physical demands (i.e., cardiorespiratory, metabolic, etc.) |
| **Step 2:** Exercise Selection | Effective and ineffective exercises based on athlete’s training status, exercise experience, previous injuries, sport position, periodization schedule |
| **Step 3:** Training Frequency | Total body vs. split routines  
Frequency based on training status  
Frequency based on sport season or periodization schedule |
| **Step 4:** Exercise Order | Push-pull vs. upper-lower body approach  
Explosive vs. structural vs. accessory order influences  
Advanced strategies (i.e., compound sets, supersets, etc.) |
| **Step 5:** Training Intensity | Effective and ineffective intensity manipulations relative to athlete’s background, sport season, and periodization schedule |
| **Step 6:** Training Volume | Effective and ineffective repetition and set manipulations based on athlete’s background, sport season, and periodization schedule |
| **Step 7:** Recovery Considerations | Perceptions vs. physiological responses  
Effective and ineffective set, exercise, and training session rest periods  
Effective and ineffective strategies (i.e., active vs. passive, nutrition, etc.) |
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Eric Ebron
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**ROUND IS OUT.**
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Betaine is a component of many plants and animals and is widespread in the food supply (3). Betaine is comprised of one glycine amino acid with three methyl groups attached, and is therefore a trimethylglycine molecule. Betaine was initially discovered in sugar beets but was later found as a constituent of various other foods including wheat bran, bread, shrimp, and spinach (3). Betaine can also be produced endogenously by the liver and kidneys through the oxidation of choline (4). It has long been known for its ability to protect cells from environmental stressors such as dehydration but has more recently come under examination for its ergogenic (i.e., performance enhancement) potential (1,2,3,4,5,6,7). Because betaine is a methyl donor, in theory, it could be used to assist in the accumulation of muscular creatine and result in improved muscular performance (1). The purpose of this article is to address emerging research both supporting and refuting betaine’s capacity to promote muscular adaptations.

**Dietary and Supplemental Betaine**

Bioavailability of dietary and supplemental betaine is similar, but supplemental betaine is absorbed more rapidly than betaine from dietary sources (1). Among adult men and women, the mean daily intake of betaine is roughly 100 – 400 mg (1). Several research studies have suggested that muscular improvements can be seen with 1.25 g of supplemental betaine administered twice daily (5,6). Additionally, it appears to take several days before increased oral intake results in increased plasma levels of betaine (1).

**Mechanisms Underlying Muscular Adaptations**

As mentioned previously, betaine’s potential to improve muscular performance may be related to its ability to boost creatine stores; however, the mechanisms underlying betaine’s ergogenic potential have yet to be fully elucidated. Animal studies have demonstrated that betaine supplementation does increase muscular creatine concentration; though, these results have not been replicated in humans (4). While supportive research is preliminary and additional investigations are warranted to understand exactly how betaine improves muscular endurance, strength, and power, it has also been suggested that betaine improves performance through its potential ability to increase protein synthesis through intracellular hyper-hydration (1,3,7).

**Impact of Betaine on Muscular Performance**

Betaine has been shown to improve selected measures of muscular performance, but with mixed results (1). Hoffman et al. found that 15 days of betaine supplementation significantly increased the amount of squat repetitions, but not bench press repetitions or vertical jump power output (5). Conversely, Lee et al. did not find an improvement in the number of squat repetitions, but instead noted a significant increase in vertical jump power output following 14 days of betaine supplementation (6). In this study, the exercise protocol specified that dynamic squats came after the vertical jump test and isometric squat test with only a two-minute rest between exercises (6). It is possible that the exercise ordering and timing may have pre-exhausted test subjects and contributed to suboptimal muscular endurance in the lower extremities; however, the Hoffman et al. study also ordered the endurance tests after the power tests (5).

Several other investigations have also supported betaine’s capacity to boost muscular power. Chowela et al. noted a non-statistically significant (p = 0.07) trend towards improvements in vertical jump power, while Pryor et al. reported statistically significant improvements in cycling sprint power after just one week of supplemental betaine (2,7).

Presently, there is little support for betaine’s ability to promote strength gains. Only a few studies have investigated this factor and the majority have failed to find a positive association. A recent double blind, placebo controlled, parallel trial found that betaine supplementation failed to improve muscular strength or offer synergistic benefits when paired with creatine during resistance training (4). The Chowela et al. study also noted no improvements in strength after six weeks of betaine supplementation (2). Conversely, Lee et al. reported improved maximal effort isometric bench press and squat performance following betaine supplementation, which lends support for its use in facilitating long-term adaptations (6). Despite the disparate research findings, it does appear that betaine exhibits some ergogenic potential, but it is still early in the research process and future investigations are necessary before stronger recommendations can be made.

**Conclusion**

Currently, there appears to be more evidence supporting betaine’s potential to improve muscular endurance and power rather than muscular strength. In addition, it should be noted that the studies in favor of betaine have largely relied on trained male test subjects (2,5,6). Very few research studies have included female participants, which may limit the applicable understanding of betaine supplementation across genders since females have shown to exhibit lower plasma betaine levels than males (1). Therefore, it may take higher doses to elicit an ergogenic response in females.

Furthermore, it is possible that betaine’s ability to promote muscular adaptations, either through elevating muscular creatine or some other mechanism, depends upon the subject’s fitness level (1). In summary, men currently engaged in a training program may notice performance gains as a result of approximately 250 g of daily supplemental betaine delivered in divided doses (5,6). On the other hand, female or untrained individuals would be advised to forgo betaine in favor of more established supplements until additional research becomes available.
REFERENCES

ABOUT THE AUTHOR
Debra Wein is a nationally recognized expert on health and wellness. She has nearly 20 years of experience working in the health and wellness industry and has designed award-winning programs for both individuals and corporations across the country. She is President and founder of Wellness Workdays, (www.wellnessworkdays.com) a leading provider of worksite wellness programs. Wein is also the Program Director of the Wellness Workdays Dietetic Internship, the only worksite wellness-focused internship for dietetics students interested in becoming Registered Dietitians that is approved by the Accreditation Council for Education in Nutrition and Dietetics (ACEND).

Melissa Kavanaugh received her Master's degree in Nutritional Science from Drexel University and is currently completing her supervised practice with Wellness Workdays, an accredited Dietetic Internship Program. Upon completion of her supervised practice, Kavanaugh plans to sit for the Registered Dietitian’s licensing examination. She holds both a personal training and a group fitness instruction certification from the American Council on Exercise (ACE). She teaches group toning classes and offers one-on-one personal training sessions as part of her fitness practice. After Kavanaugh obtains her Registered Dietitian’s license she plans to combine her fitness and nutritional knowledge to offer comprehensive wellness programs to her clients.
The sport of ice hockey has many of the same physical demands required by other power sports. The main differences for ice hockey reside in the playing surface, biomechanics of skating, and the substitution patterns. These differences require special attention for optimally preparing an athlete for the competitive season. In order to prepare a player for the season effectively, it is necessary to have a thorough understanding of the specific demands of the sport.

ENERGY SYSTEM CONSIDERATIONS

The energy system demands of ice hockey are unique from many sports due to the substitution patterns seen during gameplay. The game is played at a fast pace and players substitute “on the fly” during gameplay. This is in contrast to many sports including American football and basketball, where substitutions take place only during stoppages in play. Recent data from the National Hockey League (NHL) reports that forwards average shifts about 45 s in length while resting 57 – 90 s between shifts (8). This results in about 6 – 8 shifts per period for a player. It is estimated that players spend about 23 s in some form of high-intensity activity (sprinting, striding, skirmishing, etc.) during each shift (8). When looking at adenosine triphosphate (ATP) supply from individual energy systems, the phosphagen system is the dominant system for short, high-intensity activity lasting 0 – 30 s (4). After 20 – 30 s, the glycolytic system becomes the dominant supplier, while the oxidative or aerobic system supplies ATP for long duration, low-intensity activity (4). Comparing this information to the time and intensity demands of the hockey player, it can be inferred that the phosphagen and glycolytic systems supply the majority of ATP during a shift. During rest between shifts, the oxidative system is relied upon for clearance of hydrogen ions accumulated during anaerobic glycolysis and regeneration of ATP and creatine phosphate.

Research on the repeated sprint ability of ice hockey players suggests that maximal oxygen uptake (VO$_2$max), as determined on a skating treadmill, is associated with reduced fatigue during an on-ice test mimicking a game situation shift (8). An athlete with a large aerobic base may recover faster and more efficiently between repeated, high-intensity efforts, allowing them to skate harder and longer on the ice. It has also been reported that high-intensity interval training may improve ice hockey performance and is more beneficial for power sport athletes than tradition endurance training (6). It is important to train all three energy systems in order to maximize on-ice performance. Training sessions for the energy systems should take place with a specific adaptation in mind to maximize the desired adaptation without causing interfering adaptations (e.g., aerobic capacity versus anaerobic capacity). Training can be varied by utilizing different modes (e.g., skating, cycling, running, rowing, slideboard work, etc.), work times, rest times, and volumes.
STRENGTH CONSIDERATIONS
Skating requires powerful legs, strong hips, and a stable torso to allow efficient transfer of force from the body to the ice. Performance differences between lower and higher level hockey players of the same age group are suggested to be primarily due to disparities in rate of force development (RFD) (9). This could be because athletes rarely have enough time to produce maximal force in most sports movements (5). In theory, an ice hockey player with a greater RFD will therefore be faster and more powerful than one with a lower RFD. This highlights the importance of training RFD for ice hockey athletes.

A properly designed strength training program can potentially improve RFD for hockey players (9). A strength training program performed with proper instruction can help to improve coordination and motor unit recruitment allowing the athlete to increase their RFD (9). Advanced athletes will require progressively more advanced strength training to continue reaping the benefits of their training (2). For these advanced ice hockey athletes, greater focus should be given to explosive training to increase power and RFD. Power and RFD can be trained with many methods, including weight training with submaximal weights (40 - 80% one repetition maximum), plyometrics, sprinting, and Olympic-style weightlifting. Advanced athletes with sufficient levels of maximal strength can shift more of their training to focus on maximizing RFD and speed.

INJURY REDUCTION
In order to prepare a hockey player, it is important to understand common injuries and causes of injury in ice hockey. Injuries during competition cannot be fully prevented as many injuries occur because of the inherent contact in ice hockey. Research shows that over half of all injuries during a game are caused by contact (1,10). Injuries to the knee, shoulder, head (including concussions), and face are commonly caused from contact. The most common injuries occurring in practices are non-contact soft tissue injuries including strains of the hip and pelvic muscles (1). From this research, coaches can deduce strategies to prevent common injuries.

It is unlikely that injuries occurring from contact can be entirely prevented by any specific training. Concussions in sports are an important issue but there is limited research on proper prevention protocols. Training the muscles of the head and neck is commonly recommended by strength and conditioning coaches and athletic trainers as a method of concussion reduction (3). A comprehensive neck training program could consist of dynamic and static movements including but not limited to training all planes of motion consisting of flexion, extension, lateral flexion, and rotation. Hip and pelvic strains may be reduced by strengthening the hip flexors, extensors, abductors, and adductors. Along with strengthening, it is necessary to ensure ice hockey players have adequate hip mobility for all exercises in the weight room and for on-ice skating demands. Ensuring that the hips are both strong and mobile will allow the ice hockey athlete to perform proper and efficient skating mechanics on the ice (1,10).

PERIODIZATION
Implementation of a training program should be organized into a periodized model. Using a periodization model will allow the coach to plan specific phases for off-season, pre-season, in-season, and post-season training. There are many periodization models to use when designing a training program including linear, undulated, or block periodization (11). Once a periodization model is chosen, the coach designs macrocycles and microcycles planned around energy system and strength requirements. Figure 1 outlines a sample periodization annual plan for collegiate ice hockey players. It should be noted that each phase has a specific focus for training. During certain times of the year, a particular physical quality receives the majority of the training.

CONCLUSION
Ice hockey is a unique, physically demanding sport that requires periodized training to maximize performance and reduce injuries. A training program for ice hockey should take these demands into account, while specifically training the phosphagen and glycolytic energy systems. While no training program can guarantee that the ice hockey player will completely avoid injury, a well-designed training program may help in reducing the frequency and severity of injuries, as well as ensure that they are not physically outmatched on the ice.
REFERENCES

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## FIGURE 1. ICE HOCKEY ANNUAL PLAN

<table>
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<tr>
<th>MONTH</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
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<td>Work Capacity</td>
<td>Strength</td>
<td>Power</td>
<td>Speed</td>
<td>Maintenance</td>
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A STRENGTH AND CONDITIONING FRAMEWORK FOR THE MARATHON DES SABLES (ULTRA-ENDURANCE EVENT)

GARY STEBBING, PGDIP, CSCS

The number of long-distance endurance events and participation rates in these events has significantly increased in recent years (6). Even though physiologically a marathon can be described as ultra-endurance, many other endurance events are now significantly longer. It has been suggested that any event longer than six hours in duration can be classified as ultra-endurance, including events that span several days (16).

There are now in excess of one thousand ultra-endurance races worldwide, with participation numbers in the hundreds of thousands (5). Ultra-endurance events typically involve running, cycling, or multi-sport activities and can be performed in both single-day and multi-day formats while using varying terrain and extreme environments. The term “extreme environment” typically describes exposure to, or excess of, one or more stressors, commonly environmental stressors such as heat or cold, with individual capacity to tolerate exposure to these extremes varying significantly (4). Successful physical preparation for events that span hundreds of kilometers over several days requires long-term exposure to training loads that achieve the necessary training adaptations while minimizing the risk of injury and illness.

The specific factors underpinning successful ultra-endurance performance are still unclear; however, it is likely determined by a balance of elements such as quality of physical preparation, effective nutritional management, ability to cope with the environmental stressors, psychological resilience, and in multi-day events, recovery capacity. The physiological demands placed on the body in long ultra-endurance events are still largely unknown and there is a paucity of research on prolonged, multi-day endurance exercise. Some of the research that has been conducted was performed with military groups. This is unsurprising considering that events of this nature are relatively new and often take place in remote and challenging environments (7).

THE MARATHON DES SABLES

Taking place over six days in early April, the Marathon des Sables (MdS) is a multi-day foot race through the Southern Moroccan Sahara Desert where ground and environmental conditions can be very harsh. It is perhaps the best known and most iconic race of its type in the world and attracts competitors from across the world.

The MdS consists of team and individual events, as well as male, female, and age groups. Each competitor carries their own food (with a minimum mandatory requirement of 2,000 kcal per day), mandatory emergency provisions, and any small additional personal items they may wish to include. Water is rationed and distributed evenly across the day starting in the morning and then at various checkpoints on the route.

Challenges such as extreme heat, potential sandstorms, multiple changes in terrain and underfoot conditions, steep mountain-like climbs, and descents while carrying a pack weighing around 10 kg requires significant preparation and physical and mental resilience. Additionally, large sections of the MdS take place on soft sand.
The 2015 MdS covered 250 km, made up of back-to-back stages ranging from 31 km on day two to the legendary “double day” on day four, where competitors covered 91.7 km (the longest single-day total in MdS history). This included a time cut-off of 36 hr. Those who remained after the fourth day got day five as a rest day before facing a full marathon of 42.2 km on day six to complete the event.

In order to understand the challenge of the MdS, it is important to show the speed with which individuals complete the event:
- First placed athlete (male) averaged 11.69 km/hr
- First placed athlete (female) averaged 8.91 km/hr
- Position 50 averaged 7.96 km/hr
- Position 200 averaged 6.67 km/hr
- Position 1000 averaged 4.11 km/hr
- Final male and female competitors completed at an average speed of 3.17 and 3.14 km/hr, respectively

In general, masters competitors dominate ultra-endurance events (including the MdS) with the current optimal age range being 37 – 45 (5,6,11). The fastest male and female competitors are often in the 35 – 40 age bracket with a long background of consistent training (11).

### PHYSIOLOGY OF THE MARATHON DES SABLES
Relatively little is known regarding the physiological impact and optimal training approach for multi-day ultra-endurance events. Compounding the problem is the fact that many events have their own unique individual characteristics. Anecdotal reports seem to indicate success when using cardiovascular endurance training with a high volume of work, similar to marathon training.

As with all long-distance exercise, it has been suggested that a high VO₂max is likely to be important, particularly at the lower relative intensities of racing (8). A military study showed stable average work intensities of around 30 – 40% VO₂max over several days, even when sleep deprivation was a factor (7). A pacing strategy is likely a result of the multiple inputs to the central nervous system (e.g., body temperature, hydration status, perception of tiredness, etc.) (7). Heart rate does not appear to be a good measure of exertion in this type of event as effort perception appears to increase while heart rate remains stable, which suggests a participant’s perceived rate of exertion (RPE) may be a better indicator of systemic load or state (7,10).

Analysis of average individual completion times show that most participants move at relatively low speeds and will spend long amounts of time at a walking pace, posing a question regarding the need for excessive volume of running in preparation. Additionally, participants must be able to tolerate a wide variety of changing terrain and stimuli. This can include short-term high power outputs on sharp climbs and steep descents, to extended durations at low intensity on long flat sections. Since both the muscular and metabolic systems are challenged in multiple ways, it may be important to train for overall physical capacity across all of the fitness abilities rather than focus on just one system during training.

Training is typically categorized by a general or specific focus and it is important to differentiate as well as understand when to integrate and then isolate each focus during the stages of preparation. General training, or foundation training, targets adaptations to build both overall physical work capacity, and to create an athlete that is durable, stable, and solid with a relatively balanced body. Psychologically, this increase in work capacity can also build a deeper confidence in overall physical capability as well as mental resilience (13). This foundation is then transferred into the requirements of the event and the information is programmed to match the competitive environment as closely as possible.

### Key conditioning objectives:
- Aerobic ability (ability to work and move steadily at low speeds for long periods)
- Muscular endurance (low level repetitive muscular activity across the whole body, but particularly around the hip, knee, and ankle complex for multiple hours over several days)
- Strength and power endurance (hip and knee extensors) for climbing and moving over sand dunes
- Basic strength (particularly lower limb) for climbing and moving over sand dunes
- Core endurance (long periods of walking or jogging with a pack that weighs 10 – 12 kg)
- Work capacity and coordination (a body with significant and varied movement and training experience)
- Athleticism, balance, and proprioceptive abilities (varying terrain with uneven surfaces)

### CONDITIONING CONSIDERATIONS FOR THE MARATHON DES SABLES
The essence of physical training is to trigger adaptation and development that enhance the physical abilities that determine performance in an event; the specific exercises and combinations chosen are built on both the scientific literature available and the experience of the coach (14).

Ultra-endurance athletes often see injury and illness as part of life; however, these should not be seen as normal consequences of training. Rather, they should be considered as possible indicators of insufficient recovery from the combined impact of training and daily living stressors. The priority is to reach the starting line healthy and injury-free, even minor injuries or other health concerns can be magnified under the stressors of the event and may significantly increase the risk of not finishing and inducing further injury.
A STRENGTH AND CONDITIONING FRAMEWORK FOR THE MARATHON DES SABLES (ULTRA-ENDURANCE EVENT)

MANAGING TRAINING
The length of preparation time required to prepare for endurance events varies, however, a longer term training preparation is usually ideal for events like the MdS. For a relatively inexperienced participant, a 12-month preparation period may be required. Individuals with a good training background and a lot of relevant experience may require less time.

Although there are multiple ways to organize and manage training, an obsessive focus on running volume is likely unnecessary. The ability to move between walking and jogging, or to “hike” long distances is key to MdS preparation. Building the strength and physical capacity to carry a pack day after day over undulating terrain should be the basis of most participant’s preparation because it is a main component of the actual event.

Early training phases should emphasize building overall work capacity or general physical ability. Training phases should progress systematically and volume should be kept low to moderate until the final 12 – 16 weeks, where specialization is emphasized. In the specialization period leading into the event, training should integrate the physical, psychological, nutritional, technical, and recovery elements that the individual will face during the event. This includes testing all strategies and equipment that will be implemented during the race.

All adaptations achieved must then converge at the desired time (the event) through the use of tapering. Although each individual varies greatly, evidence suggests a successful taper of decreased training volume (41 – 60%) occurs starting 10 – 14 days before the ultra-endurance event (3).

Short-term variation in both the intensity and duration of loading should have a positive impact on general health and well-being as well as tolerance. The difference in physiological adaptation from high-intensity training and low-intensity training may be overplayed and the responses to both approaches may overlap and be complimentary (12).

In the general phase, running training should primarily focus on shorter distances and “speed” work using 5-km and 10-km runs as regular training distances, as well as 500-m and 1-km intervals with a 1:1 work-to-rest ratio.

At about 12 weeks out from the event, specificity progressively increases with the introduction of a weighted pack (beginning at 1 kg and gradually increasing in weight as the event approaches). Although experience with carrying a pack at race weight can be valuable, extensive work with a heavy pack can potentially increase the risk of injury, so caution should be exhibited.

RECOVERY
There is little doubt recovery is highly important to prepare ultra-endurance athletes for multi-day events (12). To promote recovery, back-to-back running and hiking days are introduced, initially two days, and building up to three days (e.g., 5 – 10 km on Friday, 10 – 15 km on Saturday, and 15 – 20 km Sunday). In the MdS this experience is invaluable; however, the distances covered on these back-to-back days should be carefully monitored and any distances greater than 35 km should be approached with caution.

CORE TRAINING
Core or trunk training is consistently used within sports conditioning programs (15). Lumbopelvic stability appears crucial to movement of the extremities, load support and management, and spinal protection (15). Performing exercises whereby the center of mass is constantly moving leads to postural adjustments that require muscular actions to maintain a stable or rigid spine. These movements are naturally aligned with how the body manages balance and should be incorporated in training for ultra-endurance events.

TRAINING CONSIDERATIONS
It is generally well accepted that the inclusion of strength training in the program for an endurance-based sport should improve endurance performance; this has been explained as due to possible neural, maximal strength, and power adaptations (1). The inclusion of both strength and endurance training within the same workout, training week, or training block is generally referred to as concurrent training. However, the potential interference between these conflicting goals or approaches to training can lead to undesirable adaptations.

Overall, the adaptive process appears to prioritize endurance adaptations over strength, although variations in the literature suggest this may be dependent on the specific training input (1). The objective for the strength and conditioning coach is to design training that is aimed at achieving a complementary, rather than interfering, response. Based on a review of literature, the following guidelines may be useful (2):

1. When the training goal is to increase strength or explosive power, minimize the amount of high-volume endurance training performed
2. Avoid strength training for 24 hr following a high-volume or exhaustive endurance session
3. When endurance is the training goal, focus on low-volume strength work and limit any training to failure scenarios
4. When both strength and endurance training are performed on the same day, perform the strength session second while aiming for at least a six-hour time gap

ATHLETE ASSESSMENTS
Participants in these events are often willing to push themselves to their limits and sometimes beyond. Recovery-based approaches to training should be a priority; however, establishing a balance between training, competition, and recovery is often a significant
challenge for ultra-endurance athletes (9). State of recovery can be reflected in various ways including physically, emotionally, and socially; assessments are therefore highly useful to the strength and conditioning coach.

Although little data exists specifically in ultra-endurance, questionnaires such as the Recovery-Stress Questionnaire (REST-Q), Daily Analysis of Life Demands for Athletes (DALDA), and Profile of Mood States (POMS), show good validity and reliability and may be useful tools (9). Heart rate variability (HRV) has potential in assessing overall well-being and recovery status on a day-to-day basis.

Training session intensity can be calculated using session rating of perceived exertion (SRPE). SRPE, rather than heart rate, is emphasized because this understanding of how to control exertion based on feeling is both important for the participants to learn and is particularly relevant in ultra-endurance events where heart rate appears less useful (7,10). Reports suggest some coaches encourage multiple competitive events in preparation; however, caution is recommended with this approach as excessive competitions during the preparation window can create a significant increase in load, volume, and intensity, as well as myriad social and psychological factors (13).

CONCLUSION
Strength and conditioning coaches can play an important role in the success of ultra-endurance event training. Many multi-day long-distance events are unique in design and environment, and therefore require a variety of physical abilities beyond just pure endurance. The MdS consists of a long hike that mixes jogging and walking across various terrain while carrying a pack. It also requires the individual to recover quickly and be able to produce exertion based on feeling is both important for the participants to learn and is particularly relevant in ultra-endurance events where heart rate appears less useful (7,10). Reports suggest some coaches encourage multiple competitive events in preparation; however, caution is recommended with this approach as excessive competitions during the preparation window can create a significant increase in load, volume, and intensity, as well as myriad social and psychological factors (13).

REFERENCES
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Strength and conditioning coaches have a unique opportunity and responsibility to teach and motivate youth athletes. Many times, a strength and conditioning coach is an athlete’s only knowledgeable source for strength and conditioning research and application in a world full of misinformation. Teaching and motivating youth athletes is no easy task. However, working with youth athletes presents many teaching and motivational opportunities for strength and conditioning coaches that can make the profession very rewarding. This article will provide insight into teaching and motivating youth athletes from a perspective based on my personal experience working with youth athletes as well as current scientific research.

TEACHING YOUTH ATHLETES

Patience is important when teaching proper strength training technique to youth athletes because many are beginners who have no strength training experience. Youth athletes should understand that it is important for them to practice technique as accurately as possible to prevent potential injury and to reap the maximal benefits of training even though it may take some time to achieve ideal technique.

Youth may learn in different ways. Although there are many learning style models used in classrooms that could help in teaching youth strength and conditioning, I prefer Fleming’s VARK model when teaching exercise technique (4,6). I have found that it helps to give my athletes the opportunity to see, hear, and practice the exercise (the read/write portion of the VARK is less applicable in this case). I incorporate three of the four parts of the VARK model to help maximize retention:

1. **Visual (V):** I demonstrate the technique properly while they watch.
2. **Auditory (A):** I verbally explain the exercise at a slow pace while using words that they can understand.
3. **Kinesthetic (K):** I let them practice the movement.

Sometimes, the athlete can naturally perform a movement correctly. Others may realize their technique problem and quickly fix it without my correction. I strive to compliment youth athletes who perform an exercise with good form or who correct errors on their own after improper technique, particularly if there are noticeable improvements from a prior set or workout. The goal of this reinforcing praise is to give the athlete a boost of self-confidence each time they hear it. If their form is incorrect after three repetitions, I correct them and answer any questions they have. I wait until after three repetitions to give my athletes a chance to make a correction on their own before I step in (as long as there is no immediate risk of injury). I have found that this sometimes works with my athletes and decreases the chances of frustration due to constant correction (3). Of course, a youth athlete should always be stopped immediately if their incorrect form is potentially dangerous for them or others around them (3).
At times I have noticed that many of my athletes become frustrated if I constantly correct them on an exercise. I feel that it is sometimes more effective when I pick battles with my athletes rather than correct every minor detail. If I sense that the athlete is getting frustrated, then I move the athlete on to another exercise before returning to the first exercise. When returning to the exercise, I encourage them to concentrate on one part of the exercise at a time as they progress towards complete, proper exercise technique. This seems to work better than continuing to frustrate them with constant correction.

For example, if the youth athlete is having a hard time with squats, I will have them focus on pushing the hips back during the squat until they can perform that part correctly. Then, I switch their focus to keeping both feet planted entirely on the ground. Finally, I teach them the difficult back positioning of the squat. Examples of incorrect squat technique are provided in Figures 1 and 2, while correct technique is depicted in Figure 3. These are some of the common improper squat techniques that I see with my athletes. These squat tips are not all-inclusive, nor are they the same with all athletes, so the strength and conditioning coach should assess each individual athlete and customize instruction accordingly. The eventual goal after focusing on one part of the movement at a time is for all parts of the exercise to combine into a successful squat.

It also helps to be familiar with common exercise technique errors. For instance, not controlling the body or the weight properly is one of the common errors I see with my athletes while performing strength exercises. This is important to correct because research has shown detrimental effects on training adaptations from improper exercise velocities (7). A good cue that I use for this problem is to “control the weight, do not let the weight control you.” There are various ways that a movement can be considered out of control, so the strength and conditioning coach should assess each athlete’s individual performance on specific exercises.

Because it is commonly assumed that sport success hinges on an athlete being strong, powerful, and in control of themselves, an object, or another opponent, I encourage my athletes to be strong in control of a weight or their own body during training. During a kettlebell swing, for example, the athlete can get out of control on the way back down, causing the back to round and potentially lead to injury. An example of a rounded back during the kettlebell swing can been seen in Figure 4. Instead, the athlete should be strong, powerful, and in control of themselves, an object, or another opponent, I encourage my athletes to be strong in control of a weight or their own body during training.

**PROGRESSION**

Proper progressions are important for youth athletes in a variety of ways, including periodized programming, training loads, volume, exercise selection, and complexity of similar muscle group exercises, to name a few. I often have my athletes start with less challenging exercises before progressing to more challenging exercises. At every step in the process, I will have them start with a light weight to ensure proper technique before adding weight. Continuing with the squat as an example, I have my athletes perform bodyweight squat technique proficiently before any weight is added. When their technique is correct and they appear to be ready to add weight, I then have them perform a kettlebell front squat or a dumbbell squat with arms to the sides. The next step I take for the squat is a light pipe or body bar that the athletes use to mimic barbell back squats. Finally, once the athletes demonstrate the ability to perform all of the progressions properly, I have them use a barbell for a weighted back squat. It is very common for my athletes to insist that they be able to add weight or try a more complicated exercise early in the process. Throughout the process, I insist that proper technique be maintained before weight is added or a more complicated exercise is performed. This progression strategy can be implemented with many different kinds of resistance training exercises to help teach youth athletes proper exercise movements that keep them safe and lead to long-term improvements (2).

Another exercise progression I use with my athletes is starting with push-ups or machine chest presses before advancing to light dumbbell bench presses and then barbell bench presses. These progressions, just like the squat progressions, are not applicable to all youth athletes; however, I have found that they work well with the majority of my athletes. Adding too much weight or moving on to more complicated movements before technique is correct, or at least proficient enough to avoid potential injury, may lead to continual dysfunction and could even lead to acute or chronic injuries.

For this reason, it is very important to stay diligent with the slow progressions no matter how much the athlete wants to move on to harder movements, heavier weights, or more challenging programs. Remember, long-term improvements are much more important than short-term successes. I try to get my youth athletes to focus on several months or years down the road rather than only thinking about today or tomorrow.

**MOTIVATING YOUTH ATHLETES TO SUCCEED**

An unmotivated athlete is typically an unsuccessful athlete. When youth athletes have similar ability levels, the more motivated ones will nearly always have the advantage. At times, substantially less talented athletes or teams can gain an advantage over more talented athletes or teams because of higher levels of motivation. Therefore, I find it beneficial to utilize unique and productive ways to motivate the youth athletes I train.

One way I try to motivate my youth athletes is to promote friendly competition with other athletes. Most of my athletes thrive under this competitive pressure because winning and losing matters to them. Typically, there is an immediate increase in effort when my athletes know something is a race or competition.

If I feel that this method of motivation will be beneficial, then I challenge these athletes against other athletes of similar ability levels in small games or competitions. The goal should always be to increase their motivation levels, not to shatter their self-
confidence. That being said, winning should never be celebrated when it is demeaning to another athlete.

Setting up friendly competition can be accomplished in various ways. For example, Figures 6 – 8 illustrate a speed and agility game called “baker’s dozen.” In this friendly competition, two youth athletes start at an even distance from a set line in the middle where an odd number of balls or objects are lined up. Upon the strength and conditioning coach’s cue, they run to the middle to grab only one ball or object at a time. After grabbing a ball or object, the youth athletes return to toss their ball into a container on their respective side. Whoever has the most balls at the end of the game wins. Various modes of movement can be implemented when approaching the line or returning to the start line (e.g., sprinting, backpedaling, shuffling, hopping, etc.). I adjust these modes of movement based on the sport and position the athlete plays and the goals of the athlete.

Another competitive game is the pro agility head-to-head race depicted in Figure 9. In this competition, youth athletes start by facing each other, waiting for the strength and conditioning coach’s cue to begin. The youth athletes will sprint five yards one direction, turn and run 10 yards in the opposite direction, and then turn around for another five-yard sprint to return to the start. The first one to complete the entire drill wins.

Although I see obvious increases in effort during competition from many of my athletes of similar ability levels, not all youth athletes will respond well to competition with others as a means for motivation. This is a legitimate concern. I avoid promoting competition with these athletes because of the fear of embarrassing them and decreasing their self-confidence. If I feel that a youth athlete would not respond well to competition with other athletes, then I promote competition with themselves as an alternative for increasing motivation.

By challenging them to improve their marks on the vertical jump, broad jump, pull-up, bench press, or other athletic tests, I attempt to help athletes find purpose and inspiration in their training without having to compete directly against another athlete. By challenging youth athletes against a clock or other variables, I often see them put forth maximum effort in their workouts to surpass their previous marks. Strength and conditioning coaches should still be mindful to progress athletes at an appropriate rate so athletes do not overtrain or injure themselves while trying to beat their marks.

Whether my youth athletes are competing against other athletes or against themselves, I encourage them to make goals that align with the S.M.A.R.T. (specific, measurable, achievable, realistic, and time-sensitive) training principle (1). I also show them how their training program will help them to reach those goals. Goals can be very motivational to youth athletes. I encourage athletes to write their goals down and review them regularly. By understanding my athletes’ goals and helping them to reach their goals, I am also attempting to trigger a boost in their self-confidence.

**INCREASING SELF-CONFIDENCE**

Many athletes, especially youth athletes, have a fragile sense of self-confidence. Strength and conditioning coaches are in a position to help increase athlete’s confidence by being supportive, helping the athletes reach their goals, and offering praise and incentives when the athletes achieve an accomplishment. The National Strength and Conditioning Association’s (NSCA) Position Statement Paper on Youth Resistance Training states that “a properly designed and supervised resistance training program can help improve the psychosocial well-being of youth,” (2). In a Roundtable Discussion on Youth Resistance Training, Mike Nitka stated his personal opinion on the relationship of training and self-confidence, “psychologically, we notice an improvement in their confidence and in their self-esteem while participating in our training program;” (5). Getting bigger, stronger, and faster can contribute to the overall self-confidence of youth athletes. Hearing that they are improving from others, particularly their strength and conditioning coach, may boost their confidence even more.

Simple comments and other forms of communication, positive or negative, can go a long way in encouraging or discouraging a youth athlete. Faigenbaum et al. suggest that the strength and conditioning coach should “focus on positive education. Youth strength and conditioning coaches who catch young athletes ‘being good’ and publicly praise them for their performance on a specific drill or exercise can enhance their self-confidence as well as the quality of the practice session,” (3). If I see a youth athlete lifting a little more, running a little faster, or performing an exercise correctly, I speak up and let them know in hopes of building up their self-confidence.

I have seen that many of my youth athletes appreciate and respect me as a strength and conditioning coach because I understand their goals and take an active interest in their sporting competitions. Another example from the personal experiences of youth experts is from Faigenbaum et al. who suggest that the strength and conditioning coach “takes the time to learn every athlete’s name, address any concerns, provide encouragement, and show a genuine interest in every player,” (3). I have always considered attendance at my athletes’ sporting events to be beneficial because I usually see a very positive reaction from them. Attending their events shows my willingness to take time and effort to support my athletes.

In addition, fist bumps, high fives, pats on the back, and helping them up after exercises on the floor are nonverbal actions that I use to encourage youth athletes and show them that I care. When youth athletes know that their strength and conditioning coach cares and wants them to succeed, they may be more likely to listen and respond positively to training programs and motivational techniques. By developing this relationship with my youth athletes,
I hope to create a stronger platform to teach and motivate. Having strong supporters can really boost the self-confidence of youth athletes.

Strength and conditioning coaches might be surprised by how much influence they have on the mentality of their youth athletes. Many of my youth athletes love to be bragged about in front of their friends, family, and sports coaches, and may keep comments like this in their minds and thrive on them. I also encourage my athletes through text messages, tweets, Facebook posts, and hand-written notes whenever appropriate. I consider it crucial to always be in control of my emotions and words, and to always strive to be a positive influence for my youth athletes.

Incentives are another great way to motivate athletes and increase their self-confidence when they achieve that incentive level. My athletes enjoy various types of clothing and sports accessories. A gift card to a local sporting goods store with a short note stating how proud I am of them for a certain accomplishment is often a well-received reward. I post pictures on a motivational board in the training facility of them playing sports or holding a championship trophy to make them feel important or give the athlete something to strive for by looking at other athletes’ pictures (Figure 10). Incentives can be made known to the athlete ahead of time to encourage them to reach a certain level or can be given randomly when the athlete does not expect it. This can give the athlete and often needed boost of confidence. However, it should be noted that these types of incentives are not always allowed or condoned in certain circumstances, so strength and conditioning coaches should consult with facility or school policies before implementing such an incentive program.

CONCLUSION
Strength and conditioning coaches have an important responsibility and opportunity to teach and motivate youth athletes. Strength and conditioning coaches should strive to teach athletes in a way they can understand by hearing, seeing, and practicing. Mistakes are acceptable at first because exercises can be complicated, especially at a young age. Technique errors can be corrected with descriptive cues and then reinforced by expressing why proper technique and exercise progression is important. It is essential for strength and conditioning coaches to remain patient with youth athletes to avoid frustration. Enhancing motivation in youth athletes can be achieved through encouraging friendly competition with others, competition against themselves, and setting up S.M.A.R.T. goals. Supportive strength and conditioning coaches can help increase the self-confidence of youth athletes by showing up at sporting events and understanding their athlete’s goals. Using these guidelines, strength and conditioning coaches can be valuable tools for the long-term success and the physical and psychosocial development of youth athletes.

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TEACHING AND MOTIVATING YOUTH ATHLETES—A PERSONAL PERSPECTIVE

FIGURE 1. EXAMPLE OF INCORRECT SQUAT TECHNIQUE

FIGURE 2. EXAMPLE OF INCORRECT SQUAT TECHNIQUE

FIGURE 3. EXAMPLE OF CORRECT SQUAT TECHNIQUE

FIGURE 4. EXAMPLE OF INCORRECT KETTLEBELL SWING TECHNIQUE

FIGURE 5. EXAMPLE OF CORRECT KETTLEBELL SWING TECHNIQUE
SELECTION AND DESIGN OF SPORT-SPECIFIC RESISTANCE EXERCISES

JOEL BERGERON, MS, CSCS,*D, USATF-2

The job of strength and conditioning coaches is to design programs that will guide athletes toward their best possible performance. Coaches use knowledge resources such as experience, colleagues, and their own formal education to help formulate training regimens that will best serve their athletes. When faced with limited budgets, time constraints, and other responsibilities, it becomes easy to rely on tradition and experience. However, something is often lost in translation; there is no substitute for research when it comes to training athletes. Unfortunately, it is common to see coaches who are so engrained with their philosophies that they limit their athletes due to stagnant training ideas. This article is meant to highlight the concept of specificity of training with respect to exercise selection and design with the intention of helping create proper program design.

THE CONCEPT OF SPECIFICITY
Specificity of training refers to the selection and implementation of drills, exercises, and methodologies that best contribute to training a desired movement. Specific adaptations to imposed demands, or the SAID principle, is a simple acronym describing this concept (1). In the most basic explanation, the SAID principle states the type of demand placed on the body dictates the type of adaptation that will occur (1).

Of course, performing the same movement repeatedly has several limitations. First, a plateau will eventually be reached if the body is exposed to the same stress repeatedly without variation or progression (1). Second, complex skills are more difficult to learn. Strength and conditioning coaches should create drills that mimic smaller elements of the desired movement, creating a teaching progression. With the development of these strategies, strength and conditioning coaches should determine the limiting factors within these skills. In addition, strength and conditioning coaches should consider the practicality of the drills they implement. It is important that drills have a high degree of transfer to the skills being trained. A needs analysis of the sport and assessments can help with this determination.

EXERCISE SELECTION CONSIDERATIONS TO TRAIN SPECIFICITY
During the process of exercise selection, there are several considerations, such as physiological workload, mechanical requirements, and psychological needs. Each criterion represents a specific facet of the overall assessment.

PHYSIOLOGICAL WORKLOAD
Physiological requirements refer to the bioenergetic workload placed on the athlete while performing. Fatigue directly influences each of the training facets. Metabolic training, therefore, should be one of the first assessments. Considerations for repeated efforts must be made as well. For instance, a football wide receiver may only spend four seconds during a single play, but needs to run 3 – 12 routes during each series. They also need to perform an individual warm-up and an organized team warm-up before each game. They need to run between 20 – 50 routes at near maximum effort when warm-up, preliminary, and final competitive attempts are added together, depending on where they sit on the depth chart. Their overall workload could range between 1:30 – 3:20 min of maximum effort sprinting from the beginning to the end of a game.

Energy requirements are influenced by intensity of effort. High-intensity exercise requires work within anaerobic systems, whereas low-intensity work relies more on the aerobic pathways. The majority of sports positions and game requirements call for repeated short duration max effort agility or sprinting. Sports such as baseball, soccer, football, volleyball, and tennis are examples of anaerobic activity. Each is a short duration, maximum intensity activity requiring high-energy output. Relatively lower intensity sports generally include distance running, rowing, and cross-country skiing. Table 1 provides examples of the metabolic systems. Regardless of the energy system used, an athlete who has trained to sustain higher energy output and shorter recovery times in any of the metabolic pathways possesses a competitive advantage.

Intensity also dictates the length of effort. High-intensity work quickly fatigues the body and is shorter in duration. Low-intensity performances require a sustained effort applied over a longer amount of time. Thus, aspects such as duration and intensity of the activity become relevant during the development of conditioning workouts.

Considerations for intensity should be taken into account. For example, many coaches select longer distance max effort sprints, such as 100-yard sprints, to condition their teams. The logic of this decision making is that athletes should be able to sprint at maximum effort for 12 – 15 s, recover, and repeat this workload to prepare them for competitive situations. However, there are several shortcomings with this approach. First, very few sports involve repeated maximum effort sprints covering a distance this long. In most sports and individual positions, the distance covered is not much greater than 20 yards at a time. The second issue is that an athlete who is trying to sprint 100 yards repeatedly will typically not be able to maintain their same level of speed throughout all the repetitions. Oftentimes this approach will result in athletes who are running at an intermediate jogging speed because they are too fatigued to keep the quality of their sprint at near maximal velocity. This is not an optimal method of training for high-intensity sport metabolic requirements and position characteristics.

MECHANICAL REQUIREMENTS
Mechanical requirements are the second step of the selection process. Complex movements can be broken into simpler parts using anatomical assessment. Several considerations must be made with regard to mechanical requirements including sport
position analysis, the planes that movement occurs within, the primary contributing muscle groups, and the necessary levels of strength for proper execution.

Three anatomical planes exist: sagittal, frontal, and transverse (Figure 17). Sagittal movements occur when a joint flexes or extends. The majority of movements seen in running, sprinting, and linear jumps are made in the sagittal plane. Side flexion, abduction, and adduction of joints refer to movements in the frontal plane. A significant portion of throwing motions use movements in the frontal plane; however, running and jumping also make use of this plane during the normal undulations of the pelvis and trunk seen in locomotion. Rotational movements about a vertical axis occur in the transverse plane. All throwing motions involve movements in the transverse plane, yet it is commonly neglected in most training programs, particularly rotational core strength and conditioning.

**PSYCHOLOGICAL NEEDS FOR PERFORMANCE**

The final step is determining psychological needs. It is important for strength and conditioning coaches to be aware of the specific things the athlete focuses on during competition. An example could include an athlete that performs a short, maximal intensity burst such as in a throw or jump, compared to an athlete that must spread the intensity out over time as seen in sports that utilize quarters, periods, or halftime breaks. The drills and exercises selected should mimic the mental challenge encountered by the athlete, whether that is short, high-intensity bursts, or long endurance events, to prepare the athlete’s mental state for competition.

**BRIDGING THE RESEARCH-TO-PRACTICE GAP**

A training program that successfully heeds each of the previous considerations will likely yield desired outcomes. However, all the criteria should be planned in concert to maximize the adaptation effect. When selecting and prescribing specific exercises, use of the previously described considerations should take place. The logical progression through each consideration is to prescribe exercises, drills, and workouts that simplify a skill and provide a learning progression. As basic skills are mastered, the program should build on previous points. A sound plan should allow ample time for adaptation.

Physiological and mechanical prescriptions are interrelated and should be developed as such. A balance of activities within the three planes must be prescribed as well. A common shortcoming in many programs is that the majority of the selected exercises occur predominantly in the sagittal plane. For throwing motions and jumping (e.g., volleyball and basketball), heavy reliance on sagittal exercise can be detrimental to performance because frontal and transverse movements make up a large portion of sport skills.

**EXAMPLE EXERCISES FOR SPECIFICITY**

The following example exercises are sport-specific skills for sprinters and throwers. They mimic the actual positions and needs of these athletes while providing the option for additional resistance. The descriptions explain how to perform the exercises.

**SPRINTER’S SLED PULL (FIGURES 1 – 4)**

1. Begin in the set position with a taut sled rope attached to the waist. Place chalk marks on the ground where indicated by the arrows in the images. Marks in front of the sled and each foot pedal are recommended to help set up ensuing repetitions. A partner should hold a second rope that is tied around the starting block. The partner’s job is to pull the starting block out of the way of the sled once the athlete begins the sprint.

2. Go through a normal block start progression, including a kneel, set, and sprint, using a cadence to help simulate race conditions.
SELECTION AND DESIGN OF SPORT-SPECIFIC RESISTANCE EXERCISES

This resistance training drill for sprinters works on specific explosive strength out of the blocks. It can be used throughout the training year and cycled like any other normal sprint drill for sprinting athletes. A sled weight of no greater than 15% of the athlete’s bodyweight is recommended because too heavy a load can negatively alter proper sprint mechanics. The purpose of this drill is to maximize linear displacement of the hips and maximum speed development.

THROWER’S LOW TO HIGH PULL (FIGURES 5 – 9)
1. Begin perpendicular to an adjustable pulley machine set up at about ground height with a shoulder-width stance, feet staggered using a heel-to-toe placement (toe of one foot aligns with the heel of the other foot while the feet remain parallel) and a foot placement perpendicular to the line of pull. Stand far enough away from the weight stack so that there is constant tension on the pulley throughout the movement.

2. The perform the pull, simultaneously stand upright while rotating the feet, hips, and trunk away from the weight stack. The beginning of the movement should begin with a rowing motion of one arm, and finish with a pressing motion of the other arm while maintaining a grip on the handle with both hands throughout the motion.
THROWER’S SINGLE-LEG CONTRALATERAL ROW WITH A TWIST (FIGURES 10 – 14)
1. Begin perpendicular to an adjustable pulley machine set up at about waist height, and balance on the leg closest to the pulley machine while holding the handle with the opposite hand. Stand far enough away from the weight stack so that there is constant tension on the pulley throughout the movement.

2. Lower the weight stack by straightening the arm, rotating the hand, flexing at the hip, and reaching behind with the free leg. Lower the weight until the active arm is as far as possible from the body. Raising the free leg facilitates an active counterbalance to the movement.

3. Lift the weight stack by extending at the hip first, and simultaneously rowing and twisting the arm. Focus on using the lower body first and the upper body second. Concentrate on actively maintaining balance throughout the movement as well, as it should remain a controlled movement.

4. This movement may also be performed by using the same leg and arm for added challenge. Progress to performing the movement with one eye closed, and eventually both eyes closed. Maintain balance and do not allow the free leg to touch the ground until the set is over.
BILATERAL TRUNK PULL-PRESSES (FIGURES 15 – 16)

1. Begin in an athletic position with feet staggered and knees slightly bent in the middle of a cable crossover machine, or resistance tubing on both sides.

2. Perform a standing row with one arm and simultaneously perform a chest press with the other arm. This exercise mimics the bilateral timing of the upper body seen in many sport movements; it can also be modified to mimic a sprinter’s arm mechanics.
CONCLUSION
Specificity of training involves the careful analysis of physiological, anatomical, and psychological needs for each activity. The closer a training regimen mimics an actual skill, the greater potential the transfer of workout to competitive performance. It is the duty of the strength and conditioning coach to ensure that this concept is used rather than falling into a “cookie-cutter” approach with regard to exercise selection.

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