Improvement in Dynamic Balance and Core Endurance After a 6-Week Core-Stability-Training Program in High School Track and Field Athletes

Michelle A. Sandrey and Jonathan G. Mitzel

Context: Core training specifically for track and field athletes is vague, and it is not clear how it affects dynamic balance and core-endurance measures. Objective: To determine the effects of a 6-week core-stabilization-training program for high school track and field athletes on dynamic balance and core endurance. Design: Test–retest. Setting: High school in north central West Virginia. Participants: Thirteen healthy high school student athletes from 1 track and field team volunteered for the study. Interventions: Subjects completed pretesting 1 wk before data collection. They completed a 6-wk core-stabilization program designed specifically for track and field athletes. The program consisted of 3 levels with 6 exercises per level and lasted for 30 min each session 3 times per week. Subjects progressed to the next level at 2-wk intervals. After 6 wk, posttesting was conducted. Main Outcome Measures: The subjects were evaluated using the Star Excursion Balance Test (SEBT) for posteromedial (PM), medial (M), and anteromedial (AM) directions; abdominal-fatigue test (AFT); back-extensor test (BET); and side-bridge test (SBT) for the right and left sides. Results: Posttest results significantly improved for all 3 directions of the SEBT (PM, M, and AM), AFT, BET, right SBT, and left SBT. Effect size was large for all variables except for PM and AM, where a moderate effect was noted. Minimal-detectable-change scores exceeded the error of the measurements for all dependent variables. Conclusion: After the 6-wk core-stabilization-training program, measures of the SEBT, AFT, BET, and SBT improved, thus advocating the use of this core-stabilization-training program for track and field athletes.

Keywords: postural control, star excursion balance test, trunk control, multiplanar movements

The gravitational center in the lumbopelvic region is where all movements are initiated. During activity the center of gravity is constantly shifting. The musculature that surrounds the center of gravity plays a vital role in motor function by maintaining a stable base to support the body mass.1,2 Generally referred to as the core, these global and local muscles are constantly working to maintain posture, absorb loads, protect neural structures, and assist in changing postures and dynamic movements. The core muscles transfer force and act as a bridge between the upper and lower extremities.3 Perhaps more important, the core muscles help passive structures protect and support the spine. Considering the sensitivity and quantity of nerves that run through the low back, limiting displacement and maintaining the structural integrity of this region is of great importance.

The concepts of core stabilization, strengthening, or endurance training in the sports medicine community have evolved throughout the years. Previously, core-stability exercises were widely used for the prevention and rehabilitation of injuries of the low back and lower extremities.4–8 Recently, core-stability training has been purported to enhance athletic performance, but the literature has not supported these claims and, in fact, reported a small effect on performance.9–13 For aerobic performance, Stanton et al9 noted no improvement in running economy after a 6-week Swiss-ball training program, as did Sato and Mokha11 on 5-km performance and Tse et al13 for a 40-m sprint or 2000-m rowing test. When evaluating performance or strength and power tests, Lewarchick et al10 noted that a 7-week core-stability-training program in college football athletes did not improve performance. Furthermore, Nesser et al12 noted that there was no relationship between core stability and several measures of strength and power in college football athletes. In contrast, however, the use of core-stability training improved dynamic postural control11,14–16 and core endurance as noted using the Star Excursion Balance Test (SEBT) and 3 core-endurance tests including the abdominal-fatigue test, the back-extensor test, and right and left side bridging.13,17–19 It appears that the repeated activation of core musculature along with extremity movements helps improve postural control.14

As core-stability training is becoming common for all levels of athletes, track and field is no exception. The rigors of athletic competition increase the risk of injury...
as the forces and loads acting on the body rise. Track and field is a unique sport that includes running, jumping, and throwing, as well as multievent athletes who must perform in several different events. Sprinting, running, and field events require controlled postures sustained for extended periods of time and dynamic postural control during single-limb events, as well as quick and explosive movements. Multievent athletes with little to no rest between events must have a well-conditioned core, as well as other primary muscle groups. Thus, core strength and endurance are paramount and may help improve dynamic stability of the lower extremity. Core-stability-training programs for running exist, but we found only 1 core-stability-training program in the literature for track and field athletes. Improvement in core stability using the Sahrmann core-stability test and a Swiss-ball prone stabilization core-stability test after a 6-week Swiss-ball exercise program and in Star Excursion Balance Test (SEBT) reach directions using a 5-exercise 6-week core-stability-training program were noted. However, the track and field program was a review article with only suggestions for exercises to include in a core-stability-training program. Therefore, the purpose of this study was to determine the effects of a 6-week core-stability-training program for high school track and field athletes on dynamic balance and core endurance. We hypothesized that core endurance and SEBT reach directions would improve after the implementation of a 6-week core-stability-training program designed to be of benefit for track and field athletes.

Methods

The design of the study is a test–retest design with a convenience sample of high school track and field athletes who completed a supervised core-stabilization program designed for track and field athletes over a 6-week period. Measures of the SEBT (anteromedial, medial, and posteromedial), abdominal-fatigue test (AFT), back-extensor test (BET), and right and left side-bridging test (SBT) were assessed before and immediately after the 6-week intervention period.

Subjects

Initially, 20 subjects started the study (10 male and 10 female) from the track and field program at a high school in North Central WV. Thirteen student athletes completed the study (7 males and 6 females, age = 15.38 ± 1.12 y, height = 172.3 ± 10.42 cm, mass = 62.43 ± 9.01 kg). The research sample was primarily made up of middle-distance runners, distance runners, and sprinters. None of the subjects who completed the study were throwing athletes. To be included in this study subjects had to be participating in track and field at the high school and have a valid physical on file. Exclusion criteria consisted of previous lower-extremity or lumbar-spine pathology or surgery within the past 6 months; neurological, vestibular, or visual disorder in the past 6 months; and taking any medications that could affect balance. Subjects were also excluded if they were currently participating in a core-stability-training program.

Before participation each subject’s parent or guardian signed a parental consent form, while the subjects completed an assent form. Subjects were also required to answer a demographic/injury-history questionnaire, which was used to obtain anthropometric measures and injury history. The injury history was used to determine exclusion criteria. The study was approved by the institution’s Office of Research Compliance.

Procedures

Once subjects were deemed eligible they were contacted to attend an orientation meeting. During this meeting they were provided with the guidelines of the testing and their training and testing schedule. All subjects were tested 1 week before the beginning of the core-stabilization-training program (pretest) and immediately after the conclusion of the 6-week program (posttest). Pretesting and posttesting consisted of the SEBT, the BET, the AFT, and the SBT. The subjects completed the core-stability-training program 3 times per week on days during their regularly scheduled team practices. If the dates of a team meet conflicted with the training program, the training program was completed during the next practice session for that week. The core-stabilization-training program lasted approximately 30 min/session for 6 weeks for a total of 18 sessions. To maintain consistency of the exercises performed, all training-program sessions were administered and supervised by the investigator in the gymnasium at the high school.

Pretesting and Posttesting

The SEBT was used following the protocol to the exact specifications as described in the literature. The SEBT has been shown to possess relatively high intratester and intertester reliability. Validity testing remains challenging because there is no dynamic functional test that is considered the gold standard. For this test, the subject balanced on the dominant leg in the center of a star-pattern testing area. Before performing the test, a leg-length measurement from the anterosuperior iliac spine to the distal tip of the medial malleolus was taken to normalize reach distance to leg length. Each subject was then instructed to reach with the non-weight-bearing leg as far as he or she could in each of the 3 directions while maintaining single-leg stance.

During the practice session, each reach direction (anteromedial, medial, and posteromedial) was performed 4 times. This practice session was followed by a 1-minute full rest period before testing began. After the resting period, the subject performed 3 trials in each of the 3 directions. The starting direction was randomized by the subject choosing 1 of the 3 index cards labeled with the 3 directions. Reach directions were completed in a clockwise or counterclockwise direction depending on the dominant
stance leg, clockwise for the right leg and counterclockwise if standing on the left leg. The dominant leg was determined by asking which leg would be the take-off leg or the first leg out of the starting blocks. There was a 10-second rest period between directions. At any time the athlete lost his or her balance or the investigator felt the other leg was being used for support the trial was discarded and repeated.

After the SEBT the subjects were given a 5-minute break before starting the BET.17,29 For this test the subjects were placed on their stomach in a prone position with the upper body cantilevered out over a roman chair. A horizontal position was assumed with arms crossed across the chest. The length of time this position was maintained was timed using a stopwatch. The test was terminated when the subject fell below the horizontal position. The time was recorded in seconds. There was a 5-minute break after completing the BET. In a study conducted by McGill et al., a reliability coefficient of \( r = .98 \) was reported when performing the test for 5 consecutive days. A reliability coefficient was then reported for an 8-week and 5-day repeated sessions by adding these scores together for a reliability coefficient of .99 for the BET.

For the AFT,17–10,29 the subject was placed at a 45° angle, leaning slightly forward with an angled block placed behind the low back while seated on a treatment table. The test began when the block was removed. The subject remained in this position for as long as possible. The test was terminated when the upper body could no longer remain at the 45° angle. Time was recorded in seconds using a stopwatch. The subject was given a 5-minute break after completing the AFT. The coefficient of variance of the 60° flexor test was significantly greater (.67) than the coefficient of variance of the 45° flexor test (.50). As a result, the 45° flexor test was determined to be a better test of the trunk flexors than the 60° flexor test.19

The last test performed was the SBT.5,17–10,29 The side tested first was determined by flipping a coin. The subject assumed a side-lying position on a treatment table with both legs extended and placed his or her top foot in front with support using only the elbow, forearm, and feet. The hips were raised off the table with the other arm and hand across the chest resting on the opposite shoulder. The test was terminated when the hips started to sag and the body position could no longer be maintained. Time was recorded in seconds using a stopwatch. The test was repeated using the other side. McGill found reliability coefficients when performing 5 consecutive days of testing. He found a reliability coefficient of .99 for both the right and left SBT.17 After reliability scores from the 8 weeks and 5 consecutive days of testing were compared, reliability coefficients of .96 for the right SBT and .99 for the left SBT were reported.5

**Exercise Intervention**

After the initial testing, the subject performed a 6-week training period. The subjects performed exercises with the researcher 3 times a week for a maximum of 30 min/session. The 6-week protocol for the core-stabilization-training program was 3 progressive levels of exercises focusing on strengthening the abdominal, low-back, and pelvic muscles while maintaining neuromuscular control.5,6,15,20,30 The level of difficulty for the exercises was loosely based on the 5-level mastery program for core training described by Jeffreys.31 Level 1 exercises consisted of exercises in a stationary position with static contractions and then progressed to slow movements in an unstable environment. Level 2 exercises encompassed static contractions in an unstable environment and progressed to dynamic movements in a more stable environment. Finally, the third-level exercises used dynamic movements in an unstable environment followed by a progression of added resistance to an unstable environment. Every 2 weeks the subjects progressed to the next level of exercise difficulty.

With no previous core-stability-training protocol for track and field athletes, exercises in the core-stability-training program were included that would be of benefit for track and field athletes.20 Exercises included trunk flexion at the trunk in a sit-up position, as well as trunk extension, lateral flexion on both sides, and rotation on both sides. The exercises used the athlete’s own body weight, Swiss balls, medicine balls, and therapeutic resistance bands. The sets and repetitions and holding times for each exercise for each week were fixed at 3 sets of 20 seconds for isometric holding activities and 20 repetitions for activities with isotonic contractions. The subjects started at level 1 and progressed through each level according to the protocol for that particular week.31 Subjects progressed to the next level of the core-stabilization-training program at 2-week intervals to allow proper acclimation. Although subjects had to learn new tasks each week, several of the exercises were progressed from the previous weeks by simply increasing the difficulty by adding a movement or changing the surface type. This made for a relatively easy transition between weeks as all subjects completed new tasks without much difficulty. Detailed progression can be found in Table 1.

**Statistical Analysis**

Descriptive analysis consisted of means and standard deviations for pretest and posttest data for the SEBT, AFT, BET, and left and right SBT. Paired-sample \( t \) tests were used to compare pretest and posttest results for the SEBT (postero medial, medial, and anteromedial directions), BET, AFT, right SBT, and left SBT. The level of significance was set at \( P = .05 \) for all analyses. No correction for multiple comparisons was made; instead Cohen's \( d \) measures of effect size were calculated based on the mean differences of test scores (pretest and posttest) divided by the reference SD (pretest) with corresponding 95% confidence intervals (CI). The strength of effect sizes was determined as small (\( ≤ .4 \)), moderate (\( .41−.7 \)) and large (\( ≥ .71 \)).32 Because no control group was used, minimal detectable change (MDC) scores were calculated using intraclass correlation coefficients ICC\(_{3,1}\) and the standard error of measurement. MDC scores were calculated to determine the minimal change required for the dependent variables to obtain scores beyond the error of measurement. IBM/SPSS software (IBM/SPSS, Inc, Chicago, IL) version 19.0 was used for all analyses.
Results

SEBT

Descriptive statistics for the pretest and posttest data for the SEBT can be found in Table 2 along with effect size, 95% CI, and MDC. There was a significant difference for time for medial ($t = -3.910, P = .002$) and anteromedial ($t = -3.178, P = .008$) as posttest reach distances increased. The medial reach direction had a large effect size of .83. Both posteromedial (0.46) and anteromedial (0.49) had a moderate effect size. The MDC was exceeded for all 3 directions. Percent change scores ranged from 12.54 to 5.07 for the dominant leg (all subjects were right-leg dominant), with medial direction demonstrating the most change, followed by posteromedial and anteromedial.

Core-Endurance Tests

Descriptive statistics for the AFT, BET, right SBT, and left SBT can be found in Table 3. There was a significant
difference for AFT \((t = -4.917, P < .01)\) and BET \((t = -5.148, P < .01)\) as posttest times increased. Both the AFT and BET had a large strong effect size (1.27 and 1.73, respectively). MDC scores were exceeded for the AFT and BET. The AFT and BET posttest scores increased 250.88% and 120.59%, respectively.

Both the right SBT \((t = -6.067, P < .01)\) and the left SBT \((t = -4.800, P \leq .01)\) were significant as posttest times increased. Both the right SBT and left SBT had a large strong effect size (1.41 and 1.58, respectively) MDC scores were exceeded for the right SBT and left SBT. The right SBT posttest scores increased 168.34% while the left SBT posttest scores increased by 160.03%.

**Discussion**

The purpose of the current study was to examine the effects of a 6-week core-stabilization-training program in high school track and field athletes. Specifically, to observe the effects of a 6-week core-stabilization-training program on dynamic balance, and core endurance. Dynamic balance was measured with the SEBT, and core endurance was measured using the AFT, the BET, and the SBT for the right and left sides. We hypothesized that core endurance and SEBT reach directions would improve after the 6-week core-stabilization-training program designed to benefit track and field athletes. Based on the large to moderate effect sizes and exceeding the MDC, the medial and anteromedial directions represented a true change from pretest to posttest and were truly influenced by the core-stabilization-training program. All core-endurance tests, specifically the AFT, BET, and SBT for right and left sides, had a large strong effect size and exceeded the MDC, thus indicating a benefit from the core-stabilization-training program used in this study, as well.

**Dynamic-Balance Testing With the SEBT**

The SEBT is a measure of dynamic balance and postural control. The core becomes activated before gross body movements as part of the postural control system. Since the core is responsible for postural control, assessments of dynamic balance are alternatives to assess core stabilization. The 3 reach directions of the SEBT used in this study were thought to best simulate multiplanar human movement noted in track and field and would be able to evaluate balance, stability, and precise functioning that was incorporated in the core-stabilization-training program. After the intervention, significant increases were identified in the medial and anteromedial directions. This may be attributed to the abdominal bracing incorporated in the core-stabilization-training program that stabilized the core for lower-limb movement or to the fact that the subjects possessed neuromuscular control systems that were better suited to their respective movements in track and field.

Kahle and Gribble found that maximal reach distances improved for the SEBT at posttest using healthy subjects compared with a control group after a 6-week core-stability-training program. Maximum reach distances improved for anteromedial, medial, and posteromedial at posttest for the exercise group. They surmised...
that the improvements were related to contraction of the transverse abdominis, internal and external obliques, and the rectus abdominis to provide stabilization to the spine and provide a stronger base of support for lower-extremity movement. This stabilization occurs because of initiation of limb movement. Furthermore, the core-stabilization-training program improved the strength and recruitment of trunk musculature to such an extent that standing on 1 limb during the SEBT while using the opposite limb to reach may have activated the core muscles and perhaps led to greater reach distances posttest.

Sato and Mokha also evaluated dynamic postural control and performance in competitive and recreational runners after a core-stabilization-training program. They did not observe statistical significance for SEBT directions despite the improvement after 6 weeks but, rather, noted a significant interaction as the core-stabilization-training group improved average 5000-m times compared with the control group. How this improvement would help running speed or prevent injuries was not known, but a more stable base could provide more consistent movement control. Aggarwal et al compared a core-stabilization-training program with a balance-training program in recreationally active subjects using the SEBT. They also noted improvement with the medial and anteromedial directions, which was attributed to improved trunk control and improved control of the center of gravity due to activation of the local muscles and cocontraction of these muscles rather than global muscle activation that occurs during lower-extremity movement. They also had the most improvement in the medial direction. Reach directions also improved for the balance-training group, which was attributed to improved proprioception and better static control of the ankle muscles. Other studies that incorporated athletes also noted improvement in dynamic postural control. Samson et al noted this in tennis athletes compared with a group of nonathletes.

The current study used a variety of core-stabilization-training methods that included using unstable surfaces, using limb movement to challenge the postural-control system, and performing some exercises in a weight-bearing position, which may be why reach distances improved. In addition, the core-stabilization-training program did not specifically train for postural control and dynamic stability in a standing position. While postural control and dynamic stability were challenged throughout the training program, only 3 of the positions involved standing. Most often the subject was positioned in supine, prone, side-lying, or other like positions. Similarly while the latter levels of the 6-week core-stabilization-training program used exercises that involved multiplanar movements, much of the program was dedicated to uniplanar movements and stabilizations.

Core-Endurance Testing

The core-training groups saw improvements for the AFT, BET, right SBT, and left SBT with a large effect size and percent change scores. The large improvement in posttest differences in times on the AFT, BET, right SBT, and left SBT can therefore be attributed to the 6-week core-stabilization-training program. While certain track and field events such as throwing, hurdling, or jumping events may require similar patterns of core-muscle activation, the majority of the research sample did not include subjects who specifically performed these types of events, let alone on a consistent basis. The research sample was primarily made up of middle-distance runners, distance runners, and sprinters. During these running events the core is relegated to a role as a stabilizer rather than producing gross movements of the trunk and hip. The core muscles act to stabilize the spine and pelvis to decrease excessive movement and to help absorb ground-reaction forces.

Tse et al conducted similar research on 34 subjects with an average of 1 year of rowing experience from university rowing clubs. The BET and AFT performed at 60° were used to study the effects of an 8-week core-endurance-training program using 20 subjects. Similar to the findings of this study, subjects’ mean scores improved between pretest and posttest for the AFT and BET. Tse et al attributed the lack of change to dissimilarities between the training program and the testing methods. Their training program used little static training, whereas the 4 trunk-endurance tests are static and isometric in nature. However, the program used by Tse et al was not dissimilar to the one used in the current study. Although it did incorporate a good portion of activities that were static in nature, the program used in the current study became increasingly dynamic in nature by the end of the 6-week period. Stanton et al used the Sahrmann test of core stability after a 6-week Swiss-ball training program. Differences were noted with the experimental group that were related to Swiss-ball training’s improving core stability by recruitment of the core musculature regardless of the measurement technique.

It has been observed that 4-week core-training programs are not enough to produce significant changes in core-stabilization measures, and 6-week programs like the current study have produced some improvements. Whether using programs that are longer in duration will be able to produce such results is unclear. Most of the confusion is the result of the lack of standardization in the literature. There are a multitude of different training protocols or methods that may be used, but there is little research stating which methods are ideal. There has only been research that provides suggestions as to what should be included in a training protocol. This may be at least part of the reason why clinical trials struggle to find significant differences between training groups.

In the current study, the SBT produced better results with the right side than left. This may be related to the fact that all subjects were right-side dominant. The findings of Lust et al and McGill et al contrast those of the current study in that their subjects performed better on the SBT with their nondominant left side. Lust et al observed that mean times were higher for the left SBT for the baseball training group, despite not performing exercises to strengthen the quadratus lumborum.
Clinical Implications and Limitations

The core-stabilization program was developed based on commonly used exercises in the literature. We took special care to use exercises that could be easily described and would require minimal instruction, supervision, and feedback regarding technique. We attempted to include exercises in the program that would directly be of benefit to track and field athletes. However, this was limited by the lack of literature explicitly describing core training for track and field athletes. Exercises prescribed by Fredericson and Moore that would particularly be of benefit to middle-distance and distance runners were specifically included. This would entail the maintenance of abdominal bracing to promote stability of pelvis and spine and to enhance coordination and timing of the deep core musculature. Different types of bridging and other techniques that reported varying levels of success were included from previous studies. Many of the exercises selected involved static isometric holds that mirrored the core-endurance tests. Modeling the core-training program in this way resulted in greater improvements in core endurance and dynamic balance as observed in this study. Furthermore, clinical relevance was noted as all variables exceeded MDC values after the intervention. These results show that the improvements were beyond the instrument error and represent meaningful improvement to the subject for dynamic-postural control and core endurance.

The core-stabilization-training used in this study would be a good training program to use in high school track and field athletes. Based loosely on the 5-level mastery program for core training as described by Jefferys, this core-stabilization-training program relied on level of exercise difficulty to improve core endurance and dynamic-postural control. Three levels of exercise difficulty were progressed every 2 weeks. Level 1 consisted of static contractions progressing to slow movements in an unstable environment. Level 2 consisted of an unstable environment and progressed to dynamic movements in a more stable environment. The third level encompassed exercises that used dynamic movements in an unstable environment followed by added resistance to an unstable environment. Progression based on exercise difficulty is certainly one possible way for any type of track and field athlete to use supplemental strength training and dynamic movements in unstable environments with added resistance to optimize dynamic-postural stability and core endurance. Although this study used a relatively short training period (6 weeks), a full year of continuous core-stabilization training could add additional improvements. This aspect should be further evaluated.

Limitations do exist and are based on the number of subjects completing the study, the lack of a control group, and the selection of sets, repetitions, and holding times. As this is the first study to use a core-stabilization-training program for track and field athletes, only an estimation of the number of subjects needed to find significant differences can be made. The sample size was indeed small, but increasing the sample size to 300 for the SEBT using 80% power may not contribute to clinical importance. A control group of track and field athletes was not included to evaluate the core-stabilization training. However, it was noted with moderate to large effect sizes and MDC exceeding the error of the measurements for all dependent variables that postural control and core endurance were enhanced. Further investigation is warranted with a control group to verify that the changes were indeed related to the core-stabilization-training program. Sets, repetitions, and holding times of each exercise for each week were fixed at 3 sets of 20 seconds for isometric holding activities and 20 repetitions for activities with isotonic contractions. The reasoning for the number of sets and repetitions was not based on evidence but merely on our previous knowledge of sport training and best clinical practice. Future studies should address this aspect, as limited standardization is evident for sets, reps, and progression in core-stabilization-training programs.

As the core-stabilization-training program was performed in-season, the improvements that were observed between pretesting and posttesting could be due or partly due to the athletes’ regular training rather than the direct result of the core program. However, subjects did progress without much difficulty. On the other hand, all training bouts and testing were performed after the subjects had participated in their regularly scheduled practices. This may have fatigued them and prevented them from putting forth a true maximal effort during training and testing. Furthermore, not requiring subjects to master each level of the core-stabilization-training program may have resulted in suboptimal training and negatively affected performance on the posttest. Further studies using this training program should be conducted during the off-season using track and field athletes.

Conclusion

The 6-week core-stabilization-training program designed to benefit track and field athletes resulted in significant improvements in medial and anteromedial reach directions and core endurance. With significant differences and moderate to large effect sizes, with only 2 effect sizes that crossed zero, meaningful clinical improvement pretraining to postraining was evident. Furthermore, progression based on exercise difficulty is certainly one possible way for any type of track and field athlete to use supplemental strength training and dynamic movements in unstable environments with added resistance to optimize dynamic-postural stability and core endurance. However, with the small sample size used and no control group, well-designed randomized controlled trials are warranted for further investigation.

References


