# SEVEN WEEKS OF INSTABILITY AND TRADITIONAL RESISTANCE TRAINING EFFECTS ON STRENGTH, BALANCE AND FUNCTIONAL PERFORMANCE

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## ABSTRACT

Kibele, A and Behm, DG. Seven weeks of instability and traditional resistance training effects on strength, balance and functional performance. *J Strength Cond Res* 23(9): 2443–2450, 2009—The objective of the study was to compare the effect of a 7-week unstable and stable resistance training program on measures of strength, balance, and functional performance. Forty participants were divided into unstable or stable resistance training groups. Training was conducted twice a week for 7 weeks. Pre- and post-testing measures included leg extension strength, static and dynamic balance, sit-ups, long jump, hopping test for time, shuttle run, and sprint. Results showed that there was no overall difference between unstable and stable resistance training and the training effects were independent of gender. All measures except sprint time improved with training. Interaction effects demonstrated that unstable resistance training did provide an advantage for number of sit-ups performed ($p = 0.03$; 8.9%) and the right leg hopping test (6.2%; $p = 0.0001$). This study has demonstrated that instability resistance training may be considered as effective as traditional stable resistance training for inexperienced resistance trainers. Based on the present study and the literature, instability resistance training should be incorporated in conjunction with traditional stable training to provide a greater variety of training experiences without sacrificing training benefits.

**KEY WORDS** stability, sprint, shuttle run, static balance, dynamic balance

## INTRODUCTION

According to the concept of training specificity, training under unstable or unbalanced conditions may provide the instability that can occur with activities of daily living, work, and athletic environments, providing a more effective transfer of training adaptations (4). Improved balance has been shown to augment athletic performance in some studies. For example, Behm et al. (10) showed significant correlations ($p < 0.005$) between hockey skating performance and static balance tests. Kean et al. (18) reported an increase in vertical jump height following 5 weeks of instability (balance) training. Similar exercises performed under unstable (i.e., Swiss balls, inflated discs, wobble boards) as compared to stable (i.e., floor, bench) conditions have been documented to increase trunk (2,7,8,23,24) and limb (24) muscle activation and ratings of perceived exertion (23). A major advantage of an unstable training environment would be based on the importance of neuromuscular adaptations in the early stages of a resistance training program (5). Accordingly, greater instability should challenge the neuromuscular system to a greater extent than stable conditions, possibly enhancing strength gains attributed to neural adaptations. Hence instability resistance training programs may both improve athletic performance and reduce the incidence of injuries. However, the aforementioned studies involving balance or instability were not instability resistance training studies.

There have been only a few instability resistance training studies in the literature. Instability resistance training can involve resistance training exercises performed on labile bases or platforms such as balls, discs, or boards or the use of resistance implements that move freely in 3 dimensions, have a nonuniform mass distribution (i.e., water moving in a container), or tend to displace the individual's center of gravity (i.e., unilateral dumbbell presses). Five to 10 weeks of balance training with no resistance have been reported to increase vertical jump height (18), torso balance, trunk electromyographic (EMG) activity (12), discrimination of discrete ankle inversion movements (38), balance tests, and shuttle run time (41) and could be of greater benefit for functional activities that require spinal and pelvic stabilization (32).. There was no significant difference between ballistic and sensorimotor (balance exercises on unstable bases) training (4 weeks) for maximal voluntary contraction (MVC) force, but ballistic training significantly improved rate of force development (16). Hence, most instability or balance training

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studies only incorporate a balance challenge without additional resistance. Second, although the Gruber study compared sensorimotor training to resistance training of the plantar flexors and dorsiflexors, few other studies compare unstable to stable resistance training. Finally, there are no studies to our knowledge comparing lower- body and trunk instability to traditional stable resistance training (free weight and machine resistance exercises performed on stable benches and floors).

In contradiction to the concept of training specificity, most sports involve dynamic balance, whereas instability resistance training is typically performed under relatively stationary conditions. New movement patterns and especially movement patterns performed when unstable are generally learned at a low velocity, whereas most sports are conducted at high velocities, resulting in a further contradiction of training specificity (5,9). Willardson (40) comments that "anything foreign to a skill such as a stability ball, foam roller or wobble board might confuse the original neuromuscular recruitment pattern creating a negative transfer and a resulting decrement in performance" (p. 71). Whether possible improvements in static balance or stability will transfer effectively to dynamic stability is still debatable. Shimada et al. (31) reported that walking (dynamic) balance did not correlate with standing (static) balance. Nonetheless, a number of papers have shown feedforward (27) or proactive adjustments (21) with prior experience or knowledge of forthcoming perturbations resulting in a lower occurrence of balance disruptions. Hence, in these studies, prior experience permitted the individual to anticipate (feedforward) and accommodate (proactive adjustment) for the expected instability. Except in these studies, the training and testing involved the same perturbations, whereas with typical static instability devices (i.e., Swiss balls, hemispheric domes, and wobble boards), the training dynamics do not specifically match the athletic performance. Thus, because of a possible lack of training specificity, it is debatable whether instability resistance training may enhance sport or work performance.

Furthermore, instability resistance training has been reported to decrease upper- and lower- body force output (1,4,6,25), dynamic bench press force, power and velocity (20), muscular power when utilizing an unstable pendulum-like device (19), peak concentric power and force, peak eccentric power and velocity, and range of motion (ROM) during a squat (14). Overload tension on the muscle is essential for fostering strength training adaptations (5,34). A number of authors have stated that training programs to promote general and maximal strength need repetitions that provide a resistance intensity in the range of 40 to 120% of 1 repetition maximum (RM) or MVC (33,34). An unstable training environment might not provide the same intensity of overload resistance as exercises performed under stable conditions. Therefore, strength training adaptations may not be similar between the 2 training environments.

The primary objective of this study was to evaluate the lower- body and trunk training adaptations associated with resistance training under primarily unstable vs. stable conditions. Are there greater functional gains for inexperienced resistance training individuals to begin their resistance training programs by implementing instability devices or using traditional stable exercises? Because there are possible contradictions regarding the training specificity of instability resistance training, the testing measures in the present study emphasized functional tests to ascertain the transferability of training adaptations. It was hypothesized that instability resistance training would provide significantly greater training gains in the functional tests.

## METHODS

### Experimental Approach to the Problem

To evaluate the effects of short- term stable and unstable resistance lower- body training programs on functional performance measures of untrained individuals, 40 inexperienced resistance-trained men and women were randomly divided into lower- body instability and traditional resistance training groups and trained twice per week for 7 weeks. Common functional tasks such as running, hopping, jumping, and balance were evaluated with 20-m sprint, 20-m right and left leg hops (13), 4- × 9-m shuttle run, standing long jump, and static and dynamic balance tests. Trunk muscle endurance and quadriceps' strength were measured with sit- ups and erect leg extension, respectively, pre- and post-training.

### Subjects

Forty physically active university- aged sport science students were randomly distributed into 2 training groups of 20 participants each (28 men: 23.0 ± 2.4 years, 77.5 ± 8.1 kg, 182.1 ± 6.2 cm; 12 women: 22.0 ± 1.8 years, 60.7 ± 5.8 kg, 167.9 ± 6.9 cm). There were no significant anthropometric or age differences between the groups. All subjects used their right leg as their preferred kicking leg. All subjects were considered inexperienced resistance trainers because of a lack of consistent resistance-training experience. Inexperienced subjects were utilized in this experiment since Wahl and Behm (39) demonstrated that individuals with extensive experience using ground- based free weights do not experience the extent of muscle activation increases typically reported with untrained individuals when subjected to moderate levels of instability. It was hypothesized that experience with exercises such as squats and dead lifts provides sufficient balance challenges that result in balance training adaptations. Hence, experienced resistance- trained individuals may not benefit from instability resistance training to the same extent as inexperienced individuals. Subjects were informed not to make any significant changes to their diet during the testing or training program.

Subjects were informed of the experimental risks and signed an informed consent document prior to the investigation.

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The investigation was approved by the University of Kassel and Memorial University Human Investigation Committees.

### Testing

All testing was performed in a gymnasium. Prior to testing, subjects warmed up for approximately 10 minutes by light jogging and short bouts of dynamic muscle stretching.

Measures consisted of a 20-m sprint, 20-m right and left leg hops (13), 4- × 9-m shuttle run, static and dynamic balance, sit- ups, standing long jump, and erect leg extension. In the 20-m sprint test, subjects were asked to sprint a distance of 20 m while passing through 2 light barriers. At the start, subjects leaned with their backs toward a wall 1 m in front of the first light barrier, which started an electronic clock. They could start their trials by pushing off from the wall and passing through the first light barrier. The clock was stopped by passing through the second light barrier. The better of 2 consecutive trials was used for the statistical analysis. The literature illustrates excellent intraclass correlation coefficient (ICC) reliability measures of 0.89 to 0.95 for the sprint test.

The hop test provided an indication of right and left leg power and possible right vs. left leg power imbalances. In the 20-m right and left leg hop test, subjects were asked to perform single-leg hops with each leg for a distance of 20 m. Prior to hopping, subjects sprinted up to the hopping section for a distance of 15 m. Two light barriers were used to examine the time taken for the hopping distance. The better of 2 consecutive trials for each leg was used for the statistical analysis.

The shuttle run test was included as a measure of the ability to sprint and change direction. With the 4- × 9- m shuttle run, light barriers were used to measure the time. While subjects stood behind a starting line, they started the electronic clock by passing through the first light barrier. At the end of the 9- m section, subjects were asked to step with 1 foot beyond a marker while reversing running direction and sprinting back to the start where the same reversing of movement direction was required. After the fourth 9- m section, the subject passed through the second light barrier to stop the electronic clock. The better of 2 consecutive trials was used for the statistical analysis.

Static balance testing was performed for a period of 40 seconds on a wobble board. Prior to the testing, subjects had to gain a stable body posture with both arms extended laterally. The start of the testing period was announced by the experimenter when a stable body posture was reached. At that time, subjects had to alternatively touch their left shoulder with the right hand extended and the right shoulder with the left hand extended. While the shoulder was touched subjects had to keep the ipsilateral arm extended. The number of touches within 40 seconds was used as testing criteria. In situations where subjects lost the stable body position while touching the ground with the wobble board platform, the clock was stopped. The clock was restarted when a stable position was regained. The better of 2 consecutive trials was used for the statistical analysis. Wobble board balance tests from our laboratory have reported excellent reliability measures of 0.8 to 0.89 (10).

Dynamic balance testing was performed on a 3- m gymnastic beam that was located in front of a wall. Standing at the other end of the beam with the participant's back toward the direction of movement, subjects were asked to step backward until they touched the wall with 1 foot. At that time, subjects had to turn 180 degrees and proceed with their backward movement to the starting line as fast as possible. The time for both directions was used as a testing criterion. Time measurements were done with a stop watch while announcing the start with an acoustic signal. The better of 2 consecutive trials was used for the statistical analysis.

Sit- ups as an indication of abdominal endurance were started in a supine body position with the hands held at the temples and the knees flexed at approximately 90 degrees. Subjects were asked to flex their trunks up to the point when their elbows touched their knees. A researcher secured the feet to the floor to prevent sliding and lifting of the legs. The number of sit- ups within 40 seconds was used as a testing criterion. The literature indicates excellent ICC reliability scores (0.96) for this sit- up test (28).

The standing long jump was used as a test of bilateral leg power and performed with both legs together. Arm movements were permitted for support during the take-off movement. Trials were only evaluated when subjects landed properly on their feet while not falling back. The distance between the toes at start and the heels at landing was used as a testing criterion. The better of 2 consecutive trials was used for the statistical analysis. ICC reliability scores in the literature are excellent for this test, ranging from 0.93 to 0.96 (22).

An erect isometric leg extension strength was included as a measure of isometric MVC force. It was measured with a cable pull device (Takei A5002, Fitness Monitors, Wrexham, England) with an upright body posture and a knee angle of approximately 160 degrees. Subjects were asked to start the pull initially with a moderate intensity and slowly increase the intensity to maximum exertion while keeping the trunk extended to prevent for muscle injuries. The better of 2 consecutive trials was used for the statistical analysis.

### Training Programs

The 7- week training period consisted of 2 training sessions per week to achieve effective results for inexperienced strength training subjects (30). Participants were monitored during training by 1 of the researchers to ensure a full effort was applied in each session. Prior to every second training week, squats were used to test for 1 RM strength performance.

The training warm- up consisted of 10 to 15 minutes of submaximal intensity aerobic activity on stationary bikes and step machines. Subjects also performed 5 to 10 bouts of

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dynamic stretching with mild exercise intensities for the leg extensors and the arm extensors.

For each stable training session, subjects performed squats, vertical jumps, and 3 upper- body exercises (pulldowns, butterfly, bench press). Olympic squats were executed from an upright stance descending to a knee angle of approximately 90 degrees. Five sets of 12 repetitions each with 75% of 1RM were performed. Vertical jumps included 3 sets of 6 repetitions each of explosive- type countermovement jumps to be landed on a 30- cm wooden box. The 3 upper- body exercises (pulldowns, butterfly, bench press) included 3 sets of 15 repetitions at 70% of the 1 RM. The stable training sessions also included a leg press, which subjects performed 3 sets of 15 repetitions at 70% of the 1 RM during the first 2 weeks and 5 sets of 15 repetitions from the third week on. Subjects were asked to exercise at a moderate movement velocity. A 3- minute rest interval was used between all exercise sets.

The instability training program utilized the same vertical jump and upper- body exercise protocols with the same number of sets and repetitions performed. A similar Olympic squat exercise was also performed except the resistance was 50% of 1 RM executed on a wobble board, dyna-discs, or hemispherical dome (BOSU ball). The instability group also differed from the stable resistance training group in that they performed 4 trunk stabilization exercises on a Swiss ball. Trunk stabilization exercises included a supine hip extension–knee flexion combination, T bridge fall-off (with arms abducted and extended, supine trunk and knees flexed at a right angle, the shoulders are rolled to the left and right on a Swiss ball), prone hip and knee flexion combination using both legs, and a prone hip and knee flexion combination using a single leg (36). In summary the instability training group trained with stable upper- body exercises and unstable trunk and lower- body exercises, whereas the stable training group utilized exercises performed with a stable base.

*Statistical Analyses.* The Kolmogorov-Smirnov test of normality and the Levenne's test of equality of error variances were performed on all variables. There were no significant differences detected with the Levenne test and all data were normally distributed according to the Kolmogorov-Smirnov test. Hence, the data were analyzed using a 3- way analysis of variance (ANOVA) ($2 \times 2 \times 2$) with repeated measures (GB-Stat V. 7, Dynamic Microsystems, Silver Spring, Maryland, USA) on the third factor. Factors included gender, training groups (unstable and stable resistance training), and time (pre- and post-training). If significant interactions were detected, a Bonferroni-Dunn's procedure post hoc test was utilized. Significance was considered to be achieved at $p < 0.05$. Effect sizes (ES = mean change/standard deviation of the sample scores) were also calculated and reported (11). Cohen applied qualitative descriptors for the effect sizes with ratios of 0.2, 0.5, and 0.8 indicating small, moderate, and large changes, respectively. Data are described as means ± standard deviation (*SD*).

## RESULTS

There were no significant main effects found for training groups, indicating that there was no overall significant training advantage in any of the measures for instability vs. traditional stable resistance training methods. Thus, the hypothesis was rejected. In addition there were no significant main effects or interactions for gender. Hence, all the results and descriptions will combine both genders. Overall (main effect for time), all measures except sprint times and shuttle runs significantly improved with training, thus providing evidence that both training programs provided positive training adaptations. All main effects for training data are illustrated in Table 1.

### Strength and Endurance

A significant ($p = 0.001$, ES: 0.34) main effect for training was detected for erect leg extension force, indicating that strength increased by 9.5% from pre- to post-training.

There was also a main effect for training ($p < 0.0001$, ES: 0.41) with number of sit-ups completed with a 5.6% increases associated with training. There was a significant interaction effect ($p = 0.03$), which illustrated that instability resistance training increased number of sit-ups completed by 8.9%. There was no significant increase with traditional resistance training.

### Balance

There was a significant ($p < 0.0001$, ES: 0.66) 12.4% improvement in the time to traverse a balance beam and 44.8% improvement in wobble board contacts ($p < 0.0001$, ES: 2.01) with training (main effect for time).

### Functional Performance

There was a significant ($p = 0.01$, ES: 0.15) training effect with a 1.7% increase in long jump distance. The shuttle run approached significance ($p = 0.09$, ES: 0.16), demonstrating a 1.2% decrease in time with training. The time to complete the right and left legged hopping tests significantly improved 3.1% ($p < 0.0001$, ES: 0.2) and 4.4% ($p = 0.0002$, ES: 0.24), respectively, with training (main effect for time). There was also an interactive effect ($p = 0.0001$) with right leg hops gaining a significant 6.2% improvement in hop time for the instability training group. There was no significant improvement in hop time for the traditional resistance training group. There were no significant changes in sprint times.

### Squat 1 Repetition Maximum

Squat 1 RM significantly ($p < 0.0001$) increased 18.1% (ES: 0.69) and 14.1% (ES: 0.54), respectively, from weeks 2 to 4 and 4 to 6.

### Intraclass Correlation Coefficient Reliability Measures

ICC reliability measures were excellent for erect leg extension strength (0.93), shuttle run time (0.95), left and right hop tests (0.98), and dynamic balance (0.9). Static balance demonstrated very good reliability with an ICC measure of 0.73.

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**TABLE 1.** The mean ± standard deviations and *p*-values with training. There were no main effects for training groups for any measure.

| | Main effects for time (training) | Interactions |
|---|---|---|
| Leg extension strength (N) | Pre: 160.5 ± 44.9<br>Post: 175.8 ± 49.4<br>$p = 0.001$ | No significance (ns) |
| Sit-ups (number of sit-ups completed) | Pre: 37.5 ± 4.9<br>Post: 39.6 ± 5.1<br>$p < 0.0001$ | Instability pre: 35.9 ± 5.5<br>Instability post: 39.1 ± 5.5<br>$p = 0.03$ |
| Balance beam time (s) | Pre: 7.8 ± 1.4<br>Post: 6.8 ± 1.6<br>$p < 0.0001$ | ns |
| Wobble board | Pre: 73.8 ± 16.0<br>Post: 106.9 ± 27.8<br>$p < 0.0001$ | ns |
| Long jump (meters) | Pre: 2.24 ± 0.28<br>Post: 2.28 ± 0.28<br>$p = 0.01$ | ns |
| Shuttle run (s) | Pre: 9.16 ± 0.6<br>Post: 9.05 ± 0.5<br>$p = 0.09$ | ns |
| Right leg hops (s) | Pre: 4.4 ± 0.7<br>Post: 4.3 ± 0.6<br>$p = 0.0001$ | Instability pre: 4.5 ± 0.6<br>Instability post: 4.2 ± 0.5<br>$p = 0.0002$ |
| Left leg hops (s) | Pre: 4.5 ± 0.8<br>Post: 4.3 ± 0.7<br>$p = 0.0002$ | ns |
| 20- m sprint | ns | ns |
| Squat 1 repetition maximum (kg) | Week 2: 84.3 ± 21.8<br>Week 4: 99.5 ± 25.9<br>Week 6: 113.6 ± 29.6<br>$p < 0.0001$ | NA |

## DISCUSSION

The most important finding in this study was the lack of significant main effect differences in testing measures between 7 weeks of resistance training under unstable vs. stable conditions. Thus, the hypothesis was primarily rejected because there was no advantage with either instability resistance training devices or traditional stable exercises for improvements in strength or most functional measures with a short- term training program. Two interactive effects appeared that showed that instability resistance training did provide a training advantage for the number of sit-ups performed and the time to complete the right leg hop test. The group main effects can be interpreted in 2 distinct ways.

Proponents of instability resistance training could argue that an advantage of instability resistance training is that similar training adaptations are obtained with the use of lower resistive loads. A number of studies have documented that lower forces are produced when performing resistance activities under unstable conditions. Instability resistance training has been reported to decrease upper- (1,20) and lower- body force output (2,6,14,25) and upper- (19,20) and lower- body muscular power output (14). If strength adaptations are related to the resistance intensity (33,34), then how could instability resistance training with its lower loads still achieve similar strength results? Instability studies investigating force and EMG have shown that, although loads may be lower when unstable, the activation of limb-mobilizing muscles (i.e., pectorals, deltoids, triceps) as monitored by EMG activity can remain similar (1,15) or even exceed stable conditions (23,24). McBride et al. (25) reported a decrease in agonist EMG activity when unstable, similar to Behm et al. (6); however, McBride found that synergist and antagonist EMG activity were similar with both conditions. Thus, although external loads may be decreased with unstable conditions, the activation of the concerned musculature remains high. Anderson and Behm (1) suggest that activation remains high because the muscles take on greater stabilizing functions. Hence, with an unstable load or base the internal muscle tension might still provide high- intensity contractions, providing an effective training environment for the muscle as compared with stable

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conditions, even though the external force output may be reduced.

Although a number of studies have found dramatic instability-induced decreases in force of 60 to 70% (1,6), other studies have reported either minimal decreases in force and power of 6 to 10% (20) or no decrease in force with dynamic barbell chest press (15). Koshida et al. (20) suggest that such small decrements in muscular force and power may not compromise the training effect. Perhaps the extent of instability is a mitigating factor in the depression of force. Behm et al. (6) indicated that an unstable base such as a Swiss ball may permit a strength training adaptation if the instability is moderate, allowing the production of overload forces.

Furthermore, in the present study, both training groups showed similar increases in the erect isometric leg extension strength under stable testing conditions. This result might indicate that less training stress (lower resistive forces with instability training) to the leg extensor muscles may have been compensated by an improvement in the postural trunk stabilization. Hence, in the present study, the instability training group's combination of upper- body stable resistance training exercises with the implementation of moderately unstable trunk and lower- body activities could have provided sufficiently high leg and trunk muscle activation and contractile forces that permitted significant training adaptations similar to the stable resistance training group.

Because there were no main effects for training groups, opponents of instability resistance training could argue that instability devices are unnecessary because the equilibrium challenges of some daily activities are sufficient. Willardson (40) states that "the optimal method to promote increases in balance, proprioception and core stability for any given sport is to practice the skill itself on the same surface on which the skill is performed in competition" (p. 43). For example, triathletes have been reported to be more stable and less dependent on vision for postural control than controls (26). Gymnasts are reported to be more efficient at integrating and re-weighting proprioceptive inputs (37). Because many sports provide balance challenges, the practice of the specific activity may nullify the need for specialized instability devices.

The similarity of results extended to the static and dynamic balance tests. Although the stable resistance training group did not train on specialized instability devices such as Swiss balls and wobble boards, they did perform free weight squats and vertical jumps. The use of free weights does incorporate a degree of instability into the exercises (33). As the upright body acts as an inverted pendulum, there is a tendency for the center of gravity to sway (29). This sway would be magnified during a free weight squat by the additional disruptive torque of the barbell above the center of gravity. Balance is maintained by controlling the extent of sway. It could be argued that the instability of an Olympic squat provides a similar unstable environment as squats performed on unstable devices. Hamlyn et al. (17) compared free weight squats and dead lifts to unstable callisthenic activities and found greater trunk activation with the squats and dead lifts. Their study demonstrated the substantial activity of the trunk musculature needed to counterbalance the destabilizing torques or instability of the swaying body and suspended resistance.

However, Olympic- style squats performed on unstable devices can be described as a double rather than a single inverted pendulum. A double inverted pendulum may be considered as a kinetic chain with 2 major sites of instability. Whereas the first site is located at an unstable point of force insertion to the ground, the second is located near the suspension of the major mass (barbell). This greater balance challenge may have contributed to the greater improvement in the single leg hop test.

Although there was no difference between groups for the static and dynamic balance tests, the unstable training group had superior results for the right leg hop test. The hop tests were the only tests that involved a single leg. All other tests involved either both limbs moving concurrently (wobble board test for static balance, long jump) or consecutively (sprint, shuttle run, balance beam for dynamic balance). Thus, the hop test, which was performed at the participant's maximal speed on 1 leg, may have provided a greater equilibrium stress, which revealed a greater training adaptation for balance with the unstable resistance training group. There was no statistically significant advantage for the left leg hop test ($p = 0.2$). Because the majority of the population is right- hand dominant, the right leg is the dominant leg used for activities such as kicking. While kicking with the dominant leg, the nondominant leg must maintain balance. Because all the subjects were right- side kicking leg dominant, the left leg with its greater responsibility for balance when performing unilateral leg actions may not have experienced as great a balance training adaptation as the right leg.

The statistical interactions also illustrated an advantage for instability resistance training for number of sit-ups performed. A number of studies have documented higher trunk muscle activation with similar unstable vs. stable exercises (2,3,7,12,23,24,35), which could contribute to the improved sit-up performance. It could be argued that based on Hamlyn et al.'s (17) findings of greater trunk activation with squats compared to unstable callisthenic activities, the squats performed by the stable group in the present study should have provided comparable or greater trunk activation and thus similar sit-up training adaptations. Because many unstable exercises are performed in a supine or prone position, whereas squats are performed in an upright position, the concept of training mode specificity may apply, allowing for a better transfer of training adaptations for this particular supine sit- up action.

The present study found that 7 weeks of stable and unstable resistance training provided similar training adaptations. The possibility of a reduced training load associated with unstable exercises may be compensated by high muscle activation and internal muscle tension providing similar training stresses. The similar improvement in static and dynamic balance by

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the stable resistance training group may be attributed to the instability involved with controlling the disruptive torques of free weights from an upright posture. The reported high trunk activations with instability exercises performed in supine and prone positions may have contributed to the greater number of supine sit-ups performed by the instability group. The greater balance challenge presented by the maximum speed right leg hops may have revealed a balance training advantage for instability resistance training that was not apparent with the less challenging static wobble board and balance beam tests.

## PRACTICAL APPLICATIONS

Both forms of resistance training provide similar overall training benefits for strength, balance, and functional measures with inexperienced resistance trainers. Hence, inexperienced male and female resistance trainers should include both types of training so as to take advantage of the higher forces with traditional resistance training and the greater emphasis on trunk activation and balance with instability resistance training. Because previous research has reported lower force outputs while unstable, training prescriptions for instability resistance training should include higher repetition numbers (i.e., 12–15). Because core or trunk muscles have a significant postural responsibility, a high-volume approach might be necessary to induce fatigue in the preferentially recruited type I fibers and thus enable the recruitment of higher threshold type II fibers. Instability resistance exercises can be instituted within every training session to provide a balance of higher load (traditional exercises) and greater balance and endurance challenges (instability resistance exercises) to the individual.

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