The Role of Kettlebells in Strength and Conditioning: A Review of the Literature

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ABSTRACT

STUDIES SUPPORT THE USE OF KETTLEBELLS FOR IMPROVING POWER, ALTHOUGH EVIDENCE FOR USING THEM TO IMPROVE STRENGTH AND AEROBIC FITNESS IS STILL EQUIVOCAL. STUDIES INVESTIGATING THE BIOMECHANICAL PROPERTIES OF KETTLEBELL TRAINING HAVE BEEN FRUITFUL, AND IT MAY BE USEFUL FOR DEVELOPING SPRINT RUNNING PERFORMANCE AND FOR INJURY PREVENTION. HOWEVER, WE STILL DO NOT KNOW THE OPTIMAL LOADS FOR MAXIMIZING SYSTEM AND JOINT POWER PRODUCTION, HOW THE MECHANICS, JOINT MOMENTS, AND ELECTROMYOGRAPHIC ACTIVITY CHANGES AS LOADS INCREASE DURING KETTLEBELL SWINGS, NOR WHETHER KETTLEBELL TRAINING TRANSFERS TO SPORTS PERFORMANCE.

INTRODUCTION

The use of kettlebells in the United States is a recent phenomenon. As a result, researchers have just started to investigate the utility of kettlebells in strength and conditioning programs over the last few years. Of primary interest is whether kettlebells can be used to develop strength and power, and whether they are useful for improving aerobic fitness. Additionally, researchers have been interested in several biomechanical factors (muscle activity, ground reaction forces, lumbar motion, and spinal loading) associated with various kettlebell movements, with the kettlebell swing being the most commonly researched exercise.

CHRONIC EFFECTS OF KETTLEBELL TRAINING ON STRENGTH AND POWER

Several investigations have looked at strength and power changes with chronic kettlebell training. Jay et al. (8) investigated the effects of kettlebell training on postural coordination and countermovement jump height in untrained subjects. They implemented a standard 8-week kettlebell training program involving progressions from the unweighted swing to the kettlebell deadlift, to the 2-handed kettlebell swing, and finally to the 1-handed kettlebell swing. Male subjects used a 12-kg kettlebell, and female subjects used an 8-kg kettlebell. The program did not significantly improve countermovement jump height in comparison with a control group. In contrast, Lake and Lauder (10) compared the effects of a 6-week program of kettlebell swing training with a similar program of jump squats in resistance-trained athletes on maximum and explosive strength, as measured by the half squat and countermovement jump. The subjects performed Pavel Tsatsouline's Program Minimum protocol with 16-kg kettlebells for men over 70 kg of body weight and 12-kg kettlebells for men under 70 kg of body weight (see Tsatsouline (20)). It was found that both programs improved maximum and explosive strength significantly and to the same extent. It is possible that the positive results observed by the program implemented by Lake and Lauder (10) arose as a result of the heavier weights used, which may have resulted in a greater training stimulus and therefore more significant adaptations. Similarly, Otto et al. (16) compared the effects of a 6-week, 2 days per week, weightlifting or kettlebell program on maximum strength (as measured by the back squat) and explosive strength (as measured by the vertical jump and power clean) in resistance-trained subjects. The kettlebell group performed kettlebell swings, accelerated swings, and goblet squats with a 16-kg kettlebell, whereas the Olympic-style weightlifting group performed back squats and Olympic-style pull variations. Although both groups improved vertical jump similarly,

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and both groups improved strength measures, the group that performed weightlifting improved back squat and power clean by a greater amount than the kettlebell group. This seems to suggest that weightlifting leads to superior improvements in vertical sports-specific performance than kettlebell training. However, the weightlifting group performed a greater volume of work and trained with greater specificity to these 2 tests. Manocchia et al. (12) investigated the carryover of kettlebell training to strength and endurance on traditional lifts compared with a nontraining control group using a 10-week periodized program training twice per week in resistance-trained subjects. The workouts comprised a wide range of exercises and included non-kettlebell exercises such as push-ups. The kettlebell group improved their bench press 3 repetition maximum (RM) and their clean and jerk 3RM significantly in comparison with the nontraining control, thereby demonstrating increases in both strength and power. Finally, Jay et al. (7) performed a study comparing the effects of 3 days per week of kettlebell interval training over 8 weeks with a control for improving measures of back, neck, and shoulder pain, as well as back extensor strength in untrained subjects. The pain intensity of the lower back and the muscular strength of the back extensors improved more in the intervention group than in the control group.

In summary, to date, we have found 5 studies that have investigated the effects of kettlebell training on measures of strength and power (Jay et al. (8), Lake and Lauder (10), Otto et al. (16), Manocchia et al. (12), and Jay et al. (7)). Four of the studies investigated the effects on power production (Lake and Lauder (10), Otto et al. (16), Manocchia et al. (12) and Jay et al. (8)), and 4 of the studies investigated the effects on strength (Jay et al. (7), Lake and Lauder (10), Otto et al. (16), Manocchia et al. (12)). All 4 studies investigating strength transfer found that kettlebells did in fact improve strength measures. Two of the studies compared kettlebell exercises with more traditional methods. One of these found that kettlebells produced similar results, and the other found that kettlebells produced inferior results. Three of the 4 studies investigating power transfer found that kettlebells improved measures of power. Two of these studies compared kettlebells with more traditional methods and both found that kettlebells produced similar results to traditional methods of power development. Although the evidence is still very sparse, it seems that kettlebell training is more likely to demonstrate useful improvements in power than in strength, however it is noted that in all of these studies, very light weights were used, and it is likely that different results might have been achieved using heavier loads.

ACUTE AND CHRONIC EFFECTS OF KETTLEBELL TRAINING ON CARDIOVASCULAR MEASURES

Several investigations have looked at either chronic changes in cardiovascular fitness or the acute physiological responses to kettlebell training. Jay et al. (7) performed a study comparing the effects of 3 days per week of kettlebell interval training over 8 weeks with a control for improving measures of back, neck, and shoulder pain, as well as aerobic fitness in untrained subjects. They did not notice any change in aerobic fitness in relation to a control group over the 8-week period. However, the workouts used began with progressions from the unweighted swing to the kettlebell deadlift, then to the 2-handed kettlebell swing, and finally to the 1-handed kettlebell swing. Male subjects used a 12-kg kettlebell, and female subjects used an 8-kg kettlebell. The use of unloaded progressions to begin with and the relatively light loads in comparison with other studies may have resulted in inadequate training stimulus to produce any adaptations.

Three studies have investigated the acute physiological responses to kettlebell training. Schnettler et al. (19) investigated $\dot{V}O_2max$, heart rate response, and energy cost during a maximum kettlebell 5-minute snatch test, a maximum treadmill test, and heart rate response and energy cost during a less intense 20-minute kettlebell workout. They found that treadmill $\dot{V}O_2max$ was 38.9 $mL \cdot kg^{-1} \cdot min^{-1}$, whereas the kettlebell $\dot{V}O_2max$ was 31.6 $mL \cdot kg^{-1} \cdot min^{-1}$, which was 81.2% of the treadmill $\dot{V}O_2max$. During the standard 20-minute workout, they found that heart rate averaged 164 ± 15 beats per minute, which equated to 93 ± 4.5% of maximum heart rate. Farrar et al. (3) also measured oxygen cost and the heart rate response during a commonly used 12-minute kettlebell exercise routine and compared the results with the $\dot{V}O_2max$ and heart rate response measured during a maximal treadmill test. The researchers found that during the kettlebell exercise bout, the oxygen cost was 34.3 ± 5.7 $mL \cdot kg^{-1} \cdot min^{-1}$, which was 65.3 ± 9.8% of the measured $\dot{V}O_2max$ during the treadmill test. The measured heart rates were similar to those reported by Schnettler et al. (19) at 165 ± 13 beats per minute, which was 87 ± 6% of maximum heart rate. Husley et al. (6) examined the oxygen consumption and the heart rate response during a typical 10-minute kettlebell swing routine and compared it with a treadmill run at an equivalent rating of perceived exertion (RPE). The researchers observed that oxygen consumption was significantly higher for treadmill running (46.7 ± 7.3 $mL \cdot kg^{-1} \cdot min^{-1}$) than for kettlebell swings (34.1 ± 4.7 $mL \cdot kg^{-1} \cdot min^{-1}$). In fact, the average oxygen consumption during the kettlebell workout was 73% of the oxygen consumption during the treadmill workout at the same RPE. In regards to heart rate response, Husley et al. (6) found that heart rate averaged 89 ± 5.3% of age-predicted maximum for the kettlebell workout and was similar for both kettlebell (180 ± 12 beats per minute) and treadmill (177 ± 11 beats per minute) workouts.

In summary, only 1 study (Jay et al. (7)) so far has investigated the effect of a kettlebell program on aerobic fitness and found that it had no measurable effect. Three studies (Schnettler et al. (19),

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Farrar et al. (3), and Husley et al. (6)) investigated oxygen cost and heart rate response acutely during kettlebell workouts in comparison with treadmill running. In general, in these studies, the oxygen consumption during kettlebell workouts was found to be less than that observed during treadmill running at similar intensities. However in these studies, heart rate response was found to be similar in kettlebell training to that in treadmill running. The $\dot{V}O_2max$ values observed during the more challenging kettlebell workouts, which lasted between 5 and 20 minutes were higher than 60% $\dot{V}O_2max$, which would classify them as "hard" exercise according to the definitions used by the American College of Sports Medicine [see Pollock et al. (17)]. However, no studies as of yet have been able to demonstrate improvements in aerobic fitness as a result of kettlebell training.

THE BIOMECHANICS OF KETTLEBELL TRAINING

There are 2 main styles of kettlebell swing: the hip-dominant swing and the squat-dominant swing. In a previous review comparing these 2 swing types, Matthews and Cohen (13) suggested that hip-dominant kettlebell swings are an excellent alternative to traditional hamstring exercises such as the Romanian deadlift. They proposed that hip-dominant kettlebell swings are particularly useful for strength and conditioning coaches because they place a greater emphasis on rapid eccentric control of the hamstrings in stretch-shortening cycle movements than more traditional exercises and also allow training of the hamstrings at more sports-specific speeds. Unfortunately, where researchers have investigated the biomechanics of the kettlebell swing, they have not always specified exactly whether 1 type of swing was mandated for the subjects or which was generally used.

Two studies so far have investigated electromyographic (EMG) activity during kettlebell movements. Zebis et al. (23) investigated the relative muscular activity of the hamstring muscles by measuring the EMG activity of the semitendinosus, a medial hamstring, and the biceps femoris (long head), a lateral hamstring. Unfortunately, they did not specify whether a certain type of swing was mandated nor which type of swing was actually used. They found that there was greater activation of the semitendinosus than of the biceps femoris (long head) during kettlebell swings. This finding may have relevance for sports-specific training because sprint running involves greater medial than lateral hamstring activation, as Jönhagen et al. (9) and Higashihara et al. (5) have shown. Exercises such as the kettlebell swing, which activate the medial hamstrings by a greater amount than the lateral hamstrings, may therefore be useful for inclusion in a sprint running training program. Zebis et al. (23) also reported that the kettlebell swing activated the hamstrings at high degrees of hip flexion. This may suggest that the kettlebell swing could lead to improvements in strength and hypertrophy in different parts of the hamstring muscles compared with exercises that activate the hamstrings most strongly at low degrees of hip flexion such as the Nordic hamstring curl (Zebis et al. (23)). Using magnetic resonance imaging (MRI) scans, Mendiguchia et al. (15) found that the signal intensity in various regions of 3 different hamstring muscles differed depending on the exercise selected. This phenomenon can be observed in other muscle groups also. Wakahara et al. (21) reported that the muscle activation in different regions of the triceps during resistance training is associated with regional hypertrophy in those same areas. Bloomquist et al. (1) used MRI scans to record the differences in hypertrophy after programs of either deep or shallow back squats in the hamstrings and anterior thigh muscles. Different types of squats led to varying degrees of hypertrophy at each point measured along the proximal to distal length of the thigh. Strength and conditioning coaches could therefore use kettlebell swings in combination with other exercises to create an even development of strength and size at all points along the hamstring muscles. This may aid injury prevention, although further research is required in this area to confirm this suggestion.

In a second study exploring EMG activity, McGill and Marshall (14) investigated the muscle activation of various trunk, leg, and back muscles during several kettlebell movements, including the kettlebell swing, kettlebell swings with kime, kettlebell snatches, the kettlebell bottoms-up carry, and the kettlebell racked carry. According to McGill and Marshall (14), "kime" is a technique that involves a brief muscular "pulsing" at the top of a kettlebell swing in an attempt to train rapid muscle contraction-relaxation. In this study, although the researchers did not explicitly refer to the possibility of 2 types of swing being used, they did note that the subjects began the swings in a squat position, and therefore it seems likely that a squat-dominant swing was adopted. McGill and Marshall (14) found during the kettlebell swing and the kettlebell swing with kime that the gluteal activation peak occurred late in the swing cycle and was closely associated with the final degrees of hip extension. This was an interesting finding as Worrell et al. (22) reported in a dynamometer experiment that the mean percentage of gluteus maximus EMG was highest in full hip extension (0°) compared with that reached at 30, 60, or 90° of hip flexion. Whether the kettlebell swing involves maximum gluteus maximus activity at the degree of hip flexion where gluteus maximus EMG is maximal is uncertain. However, the findings of McGill and Marshall (14) suggest that the peak is not in high degrees of hip flexion. This may make kettlebell swings a useful complement to movements that involve maximal hip extension torque in high degrees of hip flexion such as squats and deadlifts. McGill and Marshall (14) also noted that the addition of kime to the swing mostly affected the abdominal muscles, with the largest increases in activation occurring in the external oblique

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muscles (101% increase in the right external obliques and 140% increase in the left). Overall, although the snatch and the swing seemed to be very similar, the researchers noted some differences in muscle activation, in that the snatch displayed greater activity in the right external obliques, the right rectus femoris, and the left internal obliques. There was little activity in the trunk, leg, and back muscles noted during the 2 types of carries. McGill and Marshall (14) also reported on shear and compressive lumbar joint loads. They found that both shear and compressive loads were the highest at the beginning of the swing. Compressive loads were 3,195 N at the bottom of the swing, whereas shear loads were 461 N. Adding kime to the swing had little effect except at the top of the swing, where both shear and compressive loads remained high, whereas they reduced significantly in comparison at the same point during normal swings. McGill and Marshall (14) commented that less shear loading is considered to be more optimal. There was little difference in spinal loads between the snatch and the swing. However, spinal loads were found to be significantly greater in the bottoms-up position carry than in the racked position carry and in normal walking.

Lake and Lauder (11) investigated the ground reaction forces and power outputs during kettlebell swings with loads up to 32 kg and compared them with both heavy back squats and jump squats. In their description of the kettlebell swing, they referred to the exercise as a hip-hinge movement and noted that the subjects were instructed to lead with the hips. This implies that a hip-dominant swing was used. It was found that the ground reaction forces were greatest in the order: heavy back squats > jump squats > kettlebell swings. They therefore concluded that kettlebell swings using loads of 32 kg or less may therefore not be optimal for developing strength. This conclusion seems to be consistent with the equivocal results of studies investigating the effects of kettlebell training on maximal strength discussed above. However, Lake and Lauder (11) also found that power outputs were similar in jump squats and kettlebell swings, particularly with the 32-kg kettlebell. They therefore suggested that kettlebell swings might be appropriate for inclusion into a power-based program. Again, this is consistent with the results of studies investigating the positive effects of kettlebell training on explosive strength discussed above. Lake and Lauder (11) also noted that the relative contribution of the horizontal and vertical components of ground reaction forces during kettlebell swings was different to that during squats. They observed that kettlebell swings had a much higher proportion of horizontal forces. They suggest that this is because the kettlebell is actively projected forwards by hip extension. Additionally, the highest net impulse that they recorded during their study was produced by the kettlebell swing with 32 kg (276 N·s), which was greater than the largest impulse recorded in the back squat, using 60% of 1RM (183 N·s) and in the jump squat, using 40% of 1RM back squat (231 N·s). Hip-dominant kettlebell swings may therefore have applications in certain sporting movements that involve hip extension to create horizontal propulsion. For example, it has been reported that horizontal ground reaction forces display greater increases than vertical ground reaction forces when accelerating to maximal velocity during sprint running (Randell et al. (18)). Hip-dominant kettlebell swings may therefore be useful for developing short-distance sprint running ability because such sprints generally involve a large acceleration phase. Kettlebell swings may also produce other different training effects because of the greater impulses generated.

SUMMARY OF CURRENT KETTLEBELL RESEARCH

There is currently very little research investigating the effects of kettlebell training on strength, power, and aerobic fitness, and most studies have concentrated on standard low-load kettlebells weighing up to 32 kg. However, the majority of studies support the use of kettlebells for improving power, the evidence for using them for improving strength and aerobic fitness is still equivocal. Studies investigating the biomechanical properties of kettlebell training have been more fruitful. Researchers have so far found that kettlebell swings in particular have certain features that may make them useful for training athletes. The summary of these findings and their practical implications is shown in Table 1.

DIRECTIONS FOR FUTURE KETTLEBELL RESEARCH

There remain many gaps in kettlebell research at the moment. However, research involving kettlebells is a rapidly growing area, so by the time this article is published, some of the information below could be outdated. Below, we offer our suggestions to future researchers, separated into 9 different categories.

LOADING

Kettlebells range broadly in size, just as dumbbells. In fact, several manufacturers sell heavy kettlebells–one particular brand sells kettlebells of 80, 88, 97, 106, 124, 150, 176, and 203 lb. Advanced strength and power athletes of larger body weight can indeed progress to the 203-lb kettlebell for swings. Just as previous research has examined barbell and dumbbell training with a variety of loads ranging from light to maximal, future studies should examine the kinematics, kinetics, and transfer of training of different loads of kettlebells.

POWER AND GROUND REACTION FORCES

We still do not know the optimal load for maximizing system power production, which takes into account the subjects' body mass and the mass of the external resistance during kettlebell swings, cleans, and snatches. Since

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Table 1 Summary of research and recommendations in relation to kettlebell swings	
Observation	**Recommendation**
Kettlebell swings seem to activate the medial hamstrings more than the lateral hamstrings in comparison with other hamstrings exercises	Kettlebell swings may be suitable for sprinters because sprint running also involves the medial hamstrings more than the lateral hamstrings
Kettlebell swings produce a higher ratio of horizontal-to-vertical ground reaction forces than jump squats or squats	Kettlebell swings may be useful for training for sporting actions involving horizontal propulsion such as sprint running
Kettlebell swings using a pronounced hip-dominant pattern may be useful for strengthening the hamstrings at sports-specific speeds and in a stretch-shortening cycle pattern	Kettlebell swings may be useful for training for stretch-shortening cycle sporting movements in sports as are found in sports such as American football, baseball, basketball, and track and field
Kettlebell swings produce greatest hamstring activity in high degrees of hip flexion, which is different from other exercises such as the Nordic hamstring curl, which produce the greatest hamstring activity in low degrees of hip flexion	Kettlebell swings may be useful for injury prevention because coaches can use several exercises that target the hamstrings at different muscle lengths and therefore produce strength and size gains evenly along the whole muscle
Kettlebell swings create peak gluteal activation at a point near full hip extension, the degree of hip flexion in which gluteal activity is highest during maximum voluntary contractions	Kettlebell swings may be useful for training the strength and power of the gluteal muscles in full hip extension as a complement to exercises that train the gluteals predominantly in hip flexion such as squats and deadlifts
Kettlebell swings using moderate loads produce a similar power output to jump squats with conventional training loads	Kettlebell swings may be useful for substituting into a power phase of programming, particularly where horizontal propulsion is required

1RM loads are not always conducive to kettlebell training, optimal loads could be reported relative to body weight. Vertical and horizontal forces must be taken into account when calculating power measurements. Moreover, we do not yet know the optimal load for maximizing individual joint power during kettlebell swings, cleans, and snatches. In particular, the optimal load for hip extension power, determined by the product of the hip extension torque and the hip extension angular velocity, should be examined. Finally, the nature of vertical and horizontal ground reaction force changes with increasing loads should be investigated.

JOINT MOTION, JOINT TORQUE, MUSCLE ACTIVATION, AND SPINAL LOADING

Studies should examine the inherent joint motions of the ankles, knees, hips, and spine with progressively heavier swings. Research needs to determine the joint moments at the knees, hips, and lumbar spine, along with the muscle activation of the quadriceps, hamstrings, gluteals, and core musculature, during kettlebell swings, cleans, and snatches of varying loads. The hip extension torque curve throughout the entire hip range of motion should be graphed. Furthermore, the compressive and sheer loading with heavier swings should be studied.

EFFECTS ON FUNCTIONAL AND EXPLOSIVE PERFORMANCE

Future research needs to examine the training effects of kettlebell swing training on functional performance. For example, sit-to-stand, balance, and gait performance in the elderly. Moreover, the effects of heavy kettlebell swing training on vertical and horizontal jumping, in addition to acceleration and maximum speed running, need to be examined in untrained, resistance-trained, and athlete populations. It would be beneficial to know whether heavy kettlebell swings can induce significant hip extensor hypertrophy as well. Finally, studies need to determine the nature of transfer between heavy kettlebell training and powerlifting and weightlifting performance, specifically examining the effects on squat, deadlift, clean, and snatch performance.

EFFECTS ON ENDURANCE PERFORMANCE

Future research could investigate the changes in aerobic fitness over a period of several weeks as a result of more typical and challenging kettlebell routines such as the 12-minute and 20-minute swing and snatch workouts used in previous acute studies (e.g., Schnettler et al. (19), Farrar et al. (3), and Husley et al. (6)). Moreover, it would be useful to compare the changes with the improvements that can be obtained in a similar period with conventional continuous treadmill training or with interval training using other conventional gym equipment

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such as cycle ergometers or rowing machines.

DIFFERENT TYPES OF SWINGS

There are different ways to swing a kettlebell. Swings can be performed with more of a squatting emphasis that places more stress on the knee joints or with more of a hinging emphasis that places more stress on the hip joints. Future research needs to clarify the differences in kinematics and kinetics, along with the transfer of training, with the different types of swing variations. The CrossFit groups prefer what has been described as an "American" swing (see Glassman (4)), whereas the Russian Kettlebell Certification use what is termed a "Russian" swing. The Russian Kettlebell Certification was previously known as the Russian Kettlebell Challenge (see Tsatsouline (20)), and both have been abbreviated as RKC. The "American" type of swing involves a greater range of kettlebell motion and a more quad-dominant style of performance (see Glassman (4)). The "Russian" type of swing involves a shorter range of kettlebell motion and a more hip-dominant style of performance (see Tsatsouline (20)).

OTHER KETTLEBELL EXERCISES

Future research should also study different kettlebell exercises. We have a great deal to learn about Turkish Get Ups, goblet squats, and other potentially effective kettlebell lifts, insofar as no studies have ascertained the key joint moments and muscular activity in comparison with similar dumbbell or barbell exercises.

COMPARISON WITH OTHER EXERCISES

We need to learn how kettlebell training compares with other training in terms of power output, muscle activation, and other measures. For example, it would be valuable to know the metabolic effects of heavy kettlebell swings versus maximal sprint running. It would also be beneficial to know whether the heavy kettlebell swing involved greater hip power production than jump squat or Olympic-style lift variations. However, it may actually be more appropriate to compare kettlebell strength and power improvements with a hip-dominant exercise, such as an explosive, submaximal deadlift, or a hex-bar deadlift jump, rather than a knee-dominant exercise, such as a squat or jump squat. Finally, research should determine whether kettlebell swing training is safer or riskier and more or less effective than traditional plyometric, heavy lower-body resistance training, or Olympic-style lift training in developing lower-body speed and power.

HOW KINEMATICS AND KINETICS CHANGE WITH EXPERIENCE

Finally, we need to learn how subjects improve their performance over time with kettlebell swing training. For example, it would be important to know how kinematics and kinetics change with 2 years of consistent kettlebell swing training.

CONCLUSION

Kettlebells can be used for all types of populations to develop physical fitness. They can be used in rehabilitation settings to develop mobility and stability, as Brumitt et al. (2) have noted. They can be used in the conditioning of endurance athletes and they can be used to improve explosiveness in power athletes. Although there is clearly still a great deal to learn about the properties of standard kettlebell training exercises and their effect on strength, power, and aerobic fitness, the research so far indicates that they could be a promising tool for strength and conditioning coaches, particularly with respect to improving lumbo-pelvic-hip complex patterning and posterior chain power during horizontal movements. However, the current body of literature is still very small, and there are many avenues to explore before it is clear how they can best be implemented into training routines.

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