KETTLEBELL SWING TRAINING IMPROVES MAXIMAL AND EXPLOSIVE STRENGTH

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ABSTRACT

Lake, JP and Lauder, MA. Kettlebell swing training improves maximal and explosive strength. *J Strength Cond Res* 26(8): 2228–2233, 2012—The aim of this study was to establish the effect that kettlebell swing (KB) training had on measures of maximum (half squat—HS—1 repetition maximum [1RM]) and explosive (vertical jump height—VJH) strength. To put these effects into context, they were compared with the effects of jump squat power training (JS—known to improve 1RM and VJH). Twenty-one healthy men (age = 18–27 years, body mass = 72.58 ± 12.87 kg) who could perform a proficient HS were tested for their HS 1RM and VJH pre- and post-training. Subjects were randomly assigned to either a KB or JS training group after HS 1RM testing and trained twice a week. The KB group performed 12-minute bouts of KB exercise (12 rounds of 30-second exercise, 30-second rest with 12 kg if $<$70 kg or 16 kg if $>$70 kg). The JS group performed at least 4 sets of 3 JS with the load that maximized peak power—Training volume was altered to accommodate different training loads and ranged from 4 sets of 3 with the heaviest load (60% 1RM) to 8 sets of 6 with the lightest load (0% 1RM). Maximum strength improved by 9.8% (HS 1RM: 165–181% body mass, $p < 0.001$) after the training intervention, and post hoc analysis revealed that there was no significant difference between the effect of KB and JS training ($p = 0.56$). Explosive strength improved by 19.8% (VJH: 20.6–24.3 cm) after the training intervention, and post hoc analysis revealed that the type of training did not significantly affect this either ($p = 0.38$). The results of this study clearly demonstrate that 6 weeks of biweekly KB training provides a stimulus that is sufficient to increase both maximum and explosive strength offering a useful alternative to strength and conditioning professionals seeking variety for their athletes.

KEY WORDS vertical jump, 1RM, ballistic exercise, training intervention

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INTRODUCTION

Over the last decade or so, kettlebell exercise has enjoyed a successful reintroduction into the fitness industry. This has been based around exercises that are predominantly ballistic, are technically relatively simple, and tend to involve the whole body; the foundation kettlebell exercise, the swing, provides an excellent example of this. Detailed description of kettlebell swing exercise can be found in pages 43–59 of Tsatsouline's *Enter the Kettlebell* (18). Briefly, swing exercise is initiated by driving the hips backward in a "hip-hinging" motion (15), loading the hamstrings while maintaining correct alignment between the back of the head, and the C8 and sacral vertebrae, and "packing" the shoulders (maintaining a neutral shoulder girdle) (18). The motion is then powerfully reversed, with the aim of projecting the hip girdle, and, as such the kettlebell, forward. The kettlebell should be vertical displaced to between hip and shoulder height, depending on the mass of the kettlebell, and swing exercise should be continued until the perceived "crispness" of the movement begins to decline.

Promoters of kettlebell exercise suggest that exercises, like the swing, can simultaneously improve muscular strength, endurance, and power, in addition to cardiorespiratory fitness (18). However, considering its popularity, scientific commentary on the efficacy of these claims is limited and remains equivocal (7,9,11,12,14). Chiu (1) reviewed the relevance of kettlebell exercise in the strength and conditioning process and explained that because the mass of commercially available kettlebells is relatively small (typically 16–40 kg), the force applied during cornerstone exercises, like the swing, would not be sufficient to improve maximum or explosive strength. However, Lake and Lauder (12) recently demonstrated that the mechanical demands of swing exercise are largely comparable with, and in some cases exceed, the mechanical demands of resistance exercises commonly used to develop lower body maximum and explosive strength. Further, Lake and Lauder (12) reported a considerable horizontal force component, which may have important implications for the development of maximum and explosive strength in athletes whose sport includes any degree of horizontal motion.

There is some research evidence to suggest that kettlebell exercise can improve measures of both maximum (1RM and

3RM) and explosive (vertical jump performance) strength (11,14). However, description of the design of the kettlebell exercise programs used in these studies has been vague. It is therefore necessary to focus research attention on clearly defined kettlebell exercise programs and establish whether they can improve measures of neuromuscular performance like maximum and explosive strength.

Kettlebell swing exercise forms the basis of Tsatsouline's "Program Minimum" (18). Also referred to as the "U.S. Department of Energy Man-Maker" (7), this program requires trainees to perform multiple rounds of swing exercise during biweekly 12-minute bouts. Farrar et al. (7) recently reported that the physiological demand of this program was sufficient to improve cardiorespiratory fitness. However, the effect that swing exercise has on maximum and explosive strength is not known. Part of the dilemma faced by strength and conditioning coaches lays in finding time and energy efficient methods of improving neuromuscular performance [or at least maintaining it during the competitive season (16)]. If the efficacy of claims made by proponents of kettlebell exercise can be supported, relatively short bouts of biweekly swing exercise might provide an alternative method of developing maximal and explosive strength.

Therefore, the aims of this study were to address points raised by Chiu (1) and limitations to existing kettlebell exercise–based research (11,14) by establishing the effect that kettlebell swing training (using Tsatsouline's Program Minimum protocol) had on measures of maximum (half squat–HS–1 repetition maximum [1RM]) and explosive (vertical jump height–VJH) lower body strength. Informed by data recently presented about the mechanical demands of swing exercise (12), it was hypothesized that short-term swing exercise would significantly improve explosive strength but might not be sufficient to improve maximal strength.

Methods

Experimental Approach to the Problem

To establish the effect that 6 weeks of kettlebell swing exercise had on maximum and explosive strength, 24 healthy men were paired according to maximum half squat strength (HS 1RM) and randomly assigned to a kettlebell swing (KB) or jump squat (JS) power training group; the JS group acted as a control group because research has shown that JS power training can improve maximum and explosive strength (3,5,10,13). After familiarization, both groups trained twice per week for 6 weeks. The KB group performed 12 rounds of 30-second swing exercise alternated with 30 seconds of rest, and the JS group, at least three sets of 3 jump squats (depending on load) with the load that maximized peak mechanical power applied to the center of mass (CM). Dependent variables of HS 1RM (maximum strength) and VJH (explosive strength) were recorded pre- and post-training and compared using two-way mixed design analysis of variance with repeated measures.

Subjects

Twenty-four men between the ages of 18 and 27 years (mass: 72.58 ± 12.87 kg; stature: 1.77 ± 0.09 m) volunteered to participate. Subjects were involved in regular university-level sport (soccer, hockey, and rugby) at the time of testing and had a minimum of 3 months resistance training experience. They were able to perform an HS with a load equal to at least 140% of their body mass. Furthermore, they had all been free of lower body pathology for at least 6 months before the study. Ethical approval for this study was gained from the Ethical Review Panel at the University of Chichester (Chichester, UK) and after a thorough explanation of the study aims, protocols, and potential risks, subjects provided written informed consent.

Procedures

Familiarization. All subjects were required to attend 6 familiarization sessions that were held over a 3-week period and separated by at least 48 hours. During these sessions, subjects practiced HS, JS, and KB exercise in that order. The HS, JS, and KB techniques were assessed and, where necessary, corrected until proficient. Both HS and JS exercises were practiced with moderate loads, although HS loads were increased progressively leading up to 1RM testing. Kettlebell swing practice was performed in accordance with the technique guidelines outlined by Tsatsouline in pages 43–59 of his *Enter the Kettlebell* book (18) and was supervised by a certified kettlebell instructor.

Training Programs. KB training program: After self-selected warm-up, the KB group performed 12 rounds of 30-second swing exercise separated by 30 seconds of rest. Subjects were instructed to perform as many swings as possible during each round using the technique criteria outlined by Tsatsouline (18), which was monitored by a certified kettlebell instructor. Men with a body mass >70 kg used a 16-kg kettlebell, whereas men with a body mass <70 kg used a 12-kg kettlebell (18). The amount of swings performed during each round was recorded and formed the basis of vocal encouragement throughout each 12-minute bout. Subjects did not perform any other resistance exercise during this 6-week period but did continue normal weekly sporting competition and team training.

JS training program: After self-selected warm-up, the JS training group performed 2 sets of 6 50% effort unloaded vertical jumps. Further warm-up sets were then performed as dictated by their individualized optimal load (2,5). Training load remained the same throughout the 6-week training period, and emphasis was placed on both achieving and increasing maximal velocity of the barbell, which was recorded using a TENDO Weightlifting Analyzer (V-104; TENDO Sports Machines, Trencin, Slovak Republic) and formed the basis of vocal encouragement provided throughout each training session. Given the differing nature and performance goals of KB and JS exercise, no attempt was made to match the between-group training volume. During this study, peak power was maximized with different loads, relative to individual HS 1RM, across the subject population, with 4 subjects maximizing peak power with 0% HS 1RM, 4 with 20%, 1 with 40%, and 3 with 60% HS 1RM. Therefore, control was exerted by reducing sets and repetitions as the load that maximized peak power increased. This can be seen in Figure 1. Subjects did not perform any other resistance exercise during this 6-week period but did continue normal weekly sports team training.

Testing. All subjects attended two (maximum strength: HS 1RM; explosive strength: vertical jump) laboratory-based testing sessions both before and after training. The first testing session occurred at least 48 hours after the last familiarization session, where maximum strength (HS 1RM) was established. Briefly, HS 1RM was obtained with a free weight plate-loaded barbell using the procedure described in Figure 1. Subjects performed 4–6, 3–4, 2–3, and 1–2 repetitions with 30, 50, 70, and 90% of their estimated 1RM, respectively; subjects then performed progressively heavier single lifts until the load could not be lifted for 2 successive attempts. Subjects rested for 3 minutes between warm-up sets and 5 minutes between maximum attempts. All HS were performed inside a power rack (Pullum Pro-R half power rack; Pullum Sports, Luton, UK) through a range of motion equivalent to 45% of their leg length (8), lightly touching the power rack support at the bottom of the movement before performing the lifting phase as quickly as possible. Subjects were then randomly assigned to either JS ($n = 12$) or KB ($n = 12$) training groups. During the course of the study, three volunteers from the KB training group withdrew.

Four to 7 days after maximum strength testing, subjects attended the second explosive strength (vertical jump) testing session. The KB group performed unloaded vertical jumps, and the JS group performed vertical jumps with no additional load, 20, 40, 60, and 80% 1RM during the pre-training test session–so that the load that maximized peak power (optimal load) could be established–and only unloaded jumping during post-training testing. All jumps were performed on an in-ground force platform (Kistler 9851; Kistler Instruments, Alton, UK) that recorded vertical ground reaction force at 500 Hz using Provec 5.0 software (Orthodata, Ludenschneid, Germany). Unloaded jumps were performed with the subject holding a metal pole on their shoulders (mass: 0.3 kg), loaded vertical jumps with a plate-loaded barbell. After a warm-up of 50% effort vertical jumps, subjects were instructed to perform maximal effort vertical jumps with load applied in ascending order, load increasing when differences recorded between the peak power applied to the CM of 2 successive trials did not exceed 5% (3). All vertical jumps were performed inside a power rack (Pullum Pro-R half power rack; Pullum Sports), the descent phase through a range of motion equivalent to 45% of subject leg length, lightly touching the power rack support at the bottom of the movement before jumping as high as they could. Subjects attended the laboratory approximately 2 hours after breakfast, having been instructed to avoid heavy resistance exercise for at least 48 hours before testing. All subjects were involved in university team sports during the training study, competing on Wednesday and either Saturday or Sunday afternoons. Therefore, wherever possible, all testing sessions were performed on Tuesday

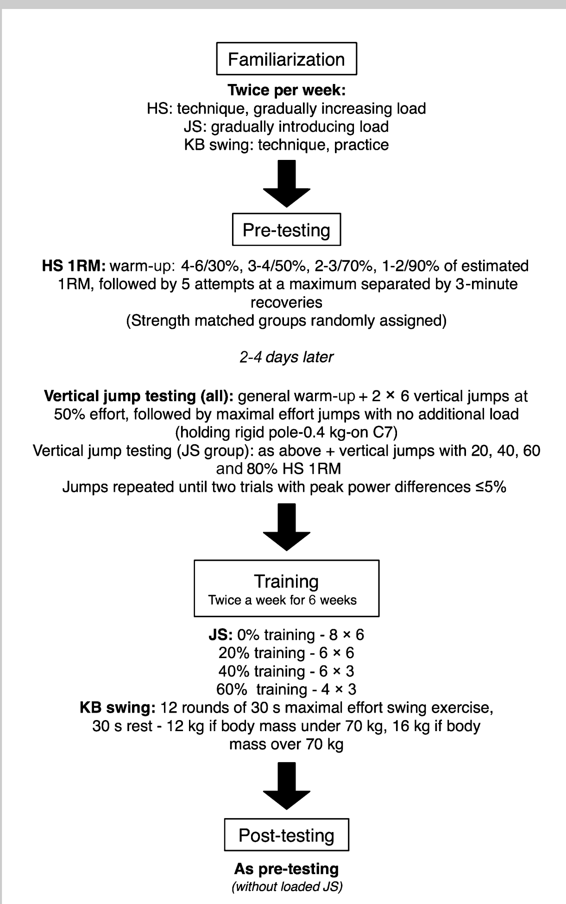

Figure 1. Schematic of the experimental procedures. HS = half squat; JS = jump squat; 1RM = 1 repetition maximum.

Table 1. Mean (*SD*) pre- and post-training half squat 1 repetition maximum (% body mass), % difference (Δ), and effect size (η^2).*

	Pre	Post	%Δ	η^2
JS	173 (32)	186 (43)	7.74 (11.15)	0.43
KB	156 (22)	174 (22)	12.03 (7.50)	0.81

*JS = jump squat.

Table 2. Mean (*SD*) pre- and post-training vertical jump height (m), % difference (Δ), and effect size (η^2).*

	Pre	Post	%Δ	η^2
JS	0.21 (0.05)	0.25 (0.06)	24 (20)	0.83
KB	0.20 (0.05)	0.23 (0.05)	15 (22)	0.60

*JS = jump squat.

mornings between 9 AM and 12 noon and all training sessions were performed on Tuesday and Friday mornings between 9 AM and 12 noon.

Jump height was calculated from vertical force-time data using the methods described by Dowling and Vamos (6), whereas HS 1RM was normalized relative to body mass. Data were processed in a customized LabVIEW program (Version 9.0; National Instruments, Austin, TX, USA). Half squat 1RM and vertical jump data demonstrated consistently high test-retest reliability with intraclass correlation (ICC) values ranging between $r = 0.93$ and 0.99.

Statistical Analyses

All data were presented as mean ($\pm$ *SD*). Furthermore, percentage pre- and post-training differences were presented and effect sizes (η^2) calculated and analyzed using methods and scales described in the literature (17). Two-way mixed design (training type) analysis of variance with repeated measures (pre- and post-training) was used to assess training effect on maximum (HS 1RM) and explosive (jump height) strength, and post hoc paired samples *t*-tests were used to assess performance changes over time, independent samples *t*-tests, the effect of the different training programs (KB and JS) on pre- to post-training differences. Statistical power was calculated as 0.988 and 0.876 for HS 1RM and jump height, respectively. All statistical analyses were performed in SPSS 17.0 (SPSS Inc., Chicago, IL, USA), and an alpha level of $p \leq 0.05$ was used to indicate statistical significance.

Results

Pre- and post-training measures of maximum (HS 1RM) and explosive (jump height) strength are presented in Tables 1 and 2, respectively. Maximum strength improved by 9.8% following the 6-week training intervention (HS 1RM: 165–181% body mass; $p = 0.0005$; $\eta^2 = 0.56$). Post hoc analysis revealed that there was no significant difference between the effect of KB and JS training ($p = 0.560$; $\eta^2 = 0.46$). Explosive strength improved by 19.8% after the 6-week training intervention (jump height: 20.6–24.3 cm; $p = 0.0007$; $\eta^2 = 0.74$). Post hoc analysis revealed that there was no significant difference between the effect of KB and JS training ($p = 0.378$; $\eta^2 = 0.41$).

Discussion

The aim of this study was to test the hypotheses, inspired by Chiu's (1) recent review, that the mechanical stimulus provided by kettlebell swing exercise is not sufficient to improve what he described as maximum strength (quantified in this study by HS 1RM) and explosive strength (quantified in this study by vertical jump performance) and limitations to existing kettlebell exercise–based research (no clearly defined program details) (11,14). To test these hypotheses, the effects of kettlebell swing exercise, performed for 12 minutes twice a week for 6 weeks [in accordance with the swing portion of Tsatsouline's Program Minimum (18)], were recorded from healthy men. A second group of healthy men acted as a control group by performing JS power training using the load that maximized individual peak power applied to the CM. The results clearly demonstrated that kettlebell swing training provides a training stimulus sufficient to improve both maximum and explosive strength.

With regard to maximum strength, kettlebell swing and JS power training both significantly improved maximum strength, and there were no significant differences between training-related improvements recorded from both training strategies. However, it is worth noting that increases in maximum strength recorded after kettlebell swing training were 12% compared with the increase of 7.7% recorded after JS power training. This is the first time that the effect that a clearly defined program of KB swing exercise has on maximum strength has been studied, so it is relatively difficult to put these findings into context. Data, although limited, have been presented about the effect that general kettlebell exercise training (no clearly defined program details) has on maximum strength (14), whereas the effect that JS power training has on maximum strength is relatively well documented (2,3,5,10,13,19). Manocchia et al. (14) reported a 25% improvement in clean and jerk strength (3RM) (30.8–38.5 kg) after 10 weeks of general kettlebell exercise. However, 3RM values indicated the study of a very weak subject population. The effect that JS power training has on maximum strength is mixed and appears to be largely dependent on relative strength. Cormie et al. (4,5) reported a 4.6% decrease in maximum strength in relatively strong men after JS power training, whereas others have reported no significant change in "recreational" athletes (2,20). However, at least 5 studies have reported increases in maximum strength–after JS power training–congruent with the results of this study (5–15%) (3–5,10,13). It is worth reiterating that the kettlebell swing–related improvements in maximum strength were achieved (a) with relatively light loads (12–16 kg) and (b) in less than half an hour of training per week. However, it is likely that considerable work is performed displacing the CM of the lifter during kettlebell swing exercise–Lake and Lauder (12) recently reported displacement of the kettlebell (combined vertical and horizontal displacement) equal to about 70% of the lifters stature–and this should be considered, particularly given the emphasis placed on horizontal projection of the kettlebell during swing exercise (12). It is likely that kettlebell swing training introduced a relatively unique training stimulus, particularly in terms of its relatively unique movement pattern, which is likely to place greater emphasis on developing both strength and endurance in the posterior chain, particularly the hamstrings, which act as stabilizers during back squat exercise. Kettlebell exercise has also been associated with increases in trunk strength (11,14), and it is also likely that this contributed to the increases in HS 1RM.

With regard to explosive strength, kettlebell swing exercise and JS power training both significantly improved explosive strength, and there were no significant differences between training-related improvements recorded from both training strategies. However, it is worth noting that increases in explosive strength recorded after kettlebell swing training were 15% compared with the 24% increase recorded after JS power training. This is not surprising and can likely be explained by movement specificity. This is the first time that the effect a clearly defined program of kettlebell swing exercise has on explosive strength has been studied so it is relatively difficult to put these findings into context. There is a paucity of research into the effect that general kettlebell exercise training (no clearly defined program details) can have on explosive strength, and the one study that did investigate this reported no significant change (14). Surprisingly, only four studies have quantified the effects that JS power training has on vertical jump performance (3,4,13,19). Increases reported by these investigators were less than effects recorded after JS power training, in this study (8–14%), but similar to effects recorded after kettlebell swing training. These results demonstrate that the subject population in this study were receptive to both training stimuli but highlights a greater applicability of JS power training to vertical jump performance. It would appear that where the relatively unique combined vertical and horizontal movement pattern of kettlebell swing exercise contributes to improvements in maximum strength, it diverts development of explosive strength when this is quantified using vertical jump performance. Therefore, kettlebell swing training may have a greater effect on horizontal explosive strength movements, like the broad jump, and, potentially, sprint performance.

Practical Applications

The results of this study clearly demonstrate that 6 weeks of biweekly kettlebell swing exercise provides a stimulus that is sufficient to increase both maximum and explosive strength, refuting the claims made to the contrary by Chiu (1). Furthermore, when combined with data presented by Farrar et al. (7), it would appear that kettlebell swing exercise provides a stimulus that can simultaneously improve cardiorespiratory fitness, maximum strength, and explosive strength, offering a useful alternative to strength and conditioning professionals seeking variety for their athletes. However, it is critical that good technique is maintained throughout the 12-minute bout protocol and that the trainee concentrates on swing technique.

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