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The Effects of Continuous One-Arm Kettlebell Swing Training on Physiological Parameters in United States Air Force Personnel: A Pilot Study

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1.0 SUMMARY

The primary aim of this study was to investigate the effects of one-arm kettlebell (KB) swing training on various U.S. Air Force (USAF) physical fitness testing components. Thirty trained male (n=15) and female (n=15) USAF subjects volunteered and were sequentially assigned to one of three groups based on 1.5-mile run time: (1) KB one-arm swing training, (2) KB one-arm swing training plus high intensity running (KB + run), and (3) traditional USAF physical training (PT) according to Air Force Instruction 36-2905. The following measurements were made before and after 10 weeks of training: 1.5-mile run, 1-minute maximal push-ups, 1-minute maximal sit-ups, maximal grip strength, pro agility, vertical jump, 40-yard dash, body weight, and percent body fat. Subjects attended three supervised exercise sessions per week for 10 weeks. During each exercise session, all groups performed a 10-minute dynamic warmup followed by either (1) 10 minutes of continuous KB swings, (2) 10 minutes of continuous KB swings plus 10 minutes of high-intensity running, or (3) 20 minutes of moderate-intensity running plus push-ups and sit-ups. Average and peak heart rates were recorded for each subject after all sessions. Paired t-tests were conducted to detect changes from pre- to post-testing within each group, and analysis of variance was used to compare between-group variability ($p \leq 0.05$). Twenty subjects completed the study. There were no statistically significant changes in 1.5-mile run time between or within groups. The 40-yard dash significantly improved within the KB swing ($p < 0.05$) and KB+ run groups ($p \leq 0.05$); however, there were no significant differences in the traditional PT group ($p \leq 0.05$) or between groups. Maximal push-ups significantly improved in the KB+ run group ($p \leq 0.05$), with no significant changes in the KB swing and traditional PT groups. This study suggests that continuous KB swing training may be used by airmen as a high-intensity, low-impact alternative to traditional USAF PT to maintain aerobic fitness and improve speed and maximal push-ups.

2.0 INTRODUCTION

The U.S. Air Force (USAF) physical fitness standards are composed of three major components: cardiorespiratory fitness, muscular strength and endurance, and body composition. Cardiorespiratory fitness is assessed with a 1.5-mile run or 1-mile walk. Muscular strength and endurance are assessed using 1-minute push-ups and sit-ups, and body composition is assessed using abdominal circumference. If an airman fails to meet the minimum required score on any of the fitness components or receives an overall score of $\leq 75\%$, the airman is given a 42- to 90-day reconditioning period before being retested.

Historically, USAF active duty men and women are expected to follow exercise guidelines outlined in Air Force Instruction (AFI) 36-2905 [1] or participate in squadron physical training (PT) sessions, based on the leadership and direction of squadron commanders. Although squadron fitness training programs are offered, they are not mandatory, and squadron commanders are only encouraged to provide guidance to their airmen describing fitness objectives and expectations. Traditional fitness guidance provided in AFI 36-2905 [1] is taken from the “gold standard” exercise guidelines recommended by the American College of Sports Medicine (ACSM) [2], which suggests participating in the following physical activity:

1. Exercise a minimum of 3 to 5 times weekly.
2. Exercise at an intensity that is between 60% and 90% of age-adjusted predicted maximum heart rate ($MHR=220-age$).
3. Perform 150 to 300 minutes per week of moderate or vigorous activity.
4. Perform a minimum of 8 to 10 separate exercises that train all major muscle groups.

When following a traditional PT program, an active duty member typically engages in 30 to 60 minutes of running or walking 3 to 5 days per week, followed by muscular strength and endurance training, specifically push-ups and sit-ups [2]. Although traditional fitness training may be adequate to meet fitness assessment standards, it has become increasingly popular for active duty members to engage in more nontraditional forms of training such as powerlifting, agility training, or kettlebell (KB) training to improve operationally relevant aspects of fitness. Alternate fitness training programs may better prepare airmen for military missions and rapid deployment. There is a need to scientifically evaluate the effectiveness of such programs in military populations for inclusion in formalized PT [3,4].

It may be advantageous for military PT leaders to learn of possible alternative forms of training, such as KB training [4]. KB training programs, such as the one used in the present study, are appealing, in part, because of their simplicity. The only equipment used is a traditional steel-like cannonball weight with a handle [5]. KB training takes less time to perform because the KB exercises are analogous to Olympic style lifting—eliciting the recruitment of multiple muscle groups with one functional movement—providing both a time-efficient and sufficient exercise stimulus. KB training has been reported to improve muscular strength, muscular endurance, power, and cardiorespiratory fitness [6-8]. Furthermore, KB exercise has been suggested as a form of PT for military personnel [4]. For example, KB training has been reported to elicit an aerobic response while simultaneously providing sufficient resistance for strengthening the musculature of the posterior chain, such as the biceps femoris, gluteus maximus, and erector spinae, which are predominantly used in running [9]. Based on a review by O'Hara et al. [4], future researchers should compare the effects of KB training programs to traditional forms of military PT programs, especially in regards to run performance, muscular strength, and injury prevention.

As reviewed previously, Lake and Lauder [6] reported that 6 weeks of 12-minute KB swing training performed bi-weekly (30-second bouts with 30 seconds rest) resulted in a 9.8% improvement in maximal strength and a 19.8% improvement in explosive strength when compared with jump squat power training to develop maximal strength and power. Neither sprinting speed nor cardiorespiratory fitness was assessed in this study to determine if the KB swings improved sprinting speed or aerobic running performance. Collectively, KB swing training provided an adequate stimulus that was sufficient to increase explosive and maximum muscular strength in this group of 21 healthy men. Furthermore, Hulsey et al. [7] reported average heart rate values greater than 85% of age-predicted MHR ($MHR=220-age$) during 10 minutes of KB swing intervals in moderately trained men and women. The high heart rate response reported by Hulsey et al. indicates that KB swings may elicit an anaerobic response in this population.

Several studies have evaluated the metabolic demands of continuous KB swings to determine if the level of aerobic stimulus meets the ACSM [1] recommendations for cardiorespiratory exercise or if KB swings can improve aerobic capacity [8-13]. Farrar et al. [11] reported an average intensity of 65% of maximum oxygen consumption during a 12-minute bout

of two-handed KB swings in highly fit college-aged men that falls into the ACSM range of 60-85% of maximum oxygen consumption for cardiorespiratory fitness. Thomas and colleagues [12] reported that combining 10 minutes of continuous KB swings and sumo deadlifts elicited similar metabolic demands as graded treadmill walking. Additionally, Falatic and colleagues [10] reported the effects of 4 weeks of high-intensity KB training on aerobic capacity in female collegiate soccer players. KB snatches were performed 3 days per week for 20 minutes with 15-second work-to-rest intervals, while the control group performed 20 minutes of free-weight and body-weight circuit training. After 4 weeks, aerobic capacity improved by 6% in the KB group, with no changes in the control group. No measurements of speed, strength, or power were assessed in this study.

The primary aim of this study was to determine if continuous one-arm KB swing training could be used to improve USAF fitness assessment scores, as well as operationally relevant aspects of fitness such as speed, power, and agility. These researchers hypothesized that KB training would improve 1.5-mile run times, muscular strength and endurance, speed, power, and agility compared to traditional USAF PT.

3.0 METHODS

The primary aim of this study was to investigate the effects of one-arm KB swing training on various USAF physical fitness testing components. Thirty trained male (n=15) and female (n=15) USAF subjects volunteered and were sequentially assigned to one of three groups based on 1.5-mile run time: (1) KB one-arm swing training (see Figure 1), (2) KB one-arm swing training plus high-intensity running (KB + run), and (3) traditional USAF PT according to AFI 36-2905.

4.0 RESULTS

Prior to training, 30 subjects were sequentially assigned to one of three training groups based on their 1.5-mile run times (Table 1). Table 2 presents subjects' pre-test characteristics. Each group consisted of 10 subjects (5 males and 5 females). Following 10 weeks of training, 20 subjects completed the study with an attrition rate of 33.3%. Only data from the subjects who completed both pre- and post-testing were included in the statistical analysis. There were no baseline significant differences between groups in any of the pre-test variables. Table 3 depicts all three study groups' pre- and post-anthropometric and physical performance data.

Three airmen in the traditional PT group were unable to complete day 2 of post-testing (1.5-mile run, push-ups, and sit-ups) due to work schedule restrictions and/or mission requirements. Therefore, data from only four of the subjects in the traditional PT group were statistically analyzed for day 2 testing. Figure 2 shows changes in the primary test variables. There were no statistically significant changes in 1.5-mile run time between or within groups ($p>0.05$). The 40-yard dash significantly improved within the KB swing group ($p\leq0.05$) and KB + run group ($p\leq0.05$). There were no significant changes noted in the traditional PT group ($p>0.05$) or between groups. Only the KB + run significantly increased 1-minute maximal push-ups ($p\leq0.05$).



(a) Starting position, front view.



(b) Starting position, side view.



(c) Ending position, front view.



(d) Ending position, side view.

Figure 1. World Kettlebell Club founder and trainer demonstrates the proper kettlebell swing technique used in the study.

Table 1. Exercise Session Breakdown

Kettlebell	Kettlebell + Run	Traditional USAF PT
<i>Dynamic Warmup</i>		
KB Swings (10 min)	KB Swings (10 min)	Run @ 60-85% HR _{max} (20 min)
	Run > 85% HR _{max} (10 min)	Calisthenics (6 min)
<i>Cool-Down (5 min)</i>		

HR_{max} = maximum heart rate.

Table 2. Subject Pre-Test Characteristics

Characteristic	Kettlebell (n = 7)	Kettlebell + Run (n = 6)	Traditional AF PT (n = 7)
Male:Female	5:2	2:4	3:4
Age (yr)	30.4 (6.9)	35.8 (4.8)	34.0 (2.9)
Height (cm)	174.0 (11.7)	167.9 (7.3)	166.5 (8.0)
Weight (kg)	81.4 (12.4)	79.5 (14.9)	81.8 (16.2)
Body Fat (%)	23.2 (8.3)	26.0 (8.3)	25.9 (7.3)

Note: Values presented as mean (standard deviation [SD]).

Table 3. Anthropomorphic and Performance Comparisons between Training Groups

Item	Kettlebell (n = 7)		Kettlebell + Run (n = 6)		Traditional AF PT (n = 7)	
	Pre	Post	Pre	Post	Pre	Post
Weight (kg)	81.4 (12.4)	79.7 (12.9)	79.5 (15.0)	80.65 (15.33)	82.9 (15.1)	83.1 (14.9)
Body Fat (%)	23.2 (8.3)	20.7 (8.6) ^a	26.0 (8.3)	26.7 (7.7)	24.5 (7.6)	23.7 (8.1)
Max Push-Ups (#/min)	40.6 (8.0)	46.7 (13.4)	24.0 (17.3)	31.7 (20.8) ^a	36.4 (10.9) ^b	47.2 (16.8) ^b
Max Sit-Ups (#/min)	47.1 (14.9)	50.3 (9.0)	43.8 (13.8)	44.0 (14.1)	44.7 (8.9) ^c	51.4 (4.7) ^c
1.5-Mile Run (mm:ss)	12:13 (1:23)	12:01 (1:14)	12:55 (1:53)	13:10 (2:05)	13:28 (1:19) ^c	14:27 (3:04) ^c
Max Grip Strength (kg)	38.9 (11.7)	42.0 (11.2)	34.4 (13.5)	35.9 (15.1)	37.9 (13.5)	40.8 (11.5)
Pro Agility (s)	5.5 (0.4)	5.5 (0.4)	6.2 (0.9)	6.1 (1.0)	5.6 (0.4) ^b	5.7 (0.5) ^b
Vertical Jump (in)	39.6 (9.4)	40.9 (10.7)	36.3 (14.7)	37.1 (14.5)	37.3 (8.1)	37.3 (9.9) ^b
40-Yard Dash (s)	6.2 (1.0)	5.8 (0.9) ^a	7.0 (1.2)	6.5 (1.0) ^a	6.2 (0.6) ^b	6.0 (0.5) ^b

Note: Values presented as mean (SD).

^aSignificantly different from pre-test ($p \leq 0.05$).

^bn = 6.

^cn = 4.

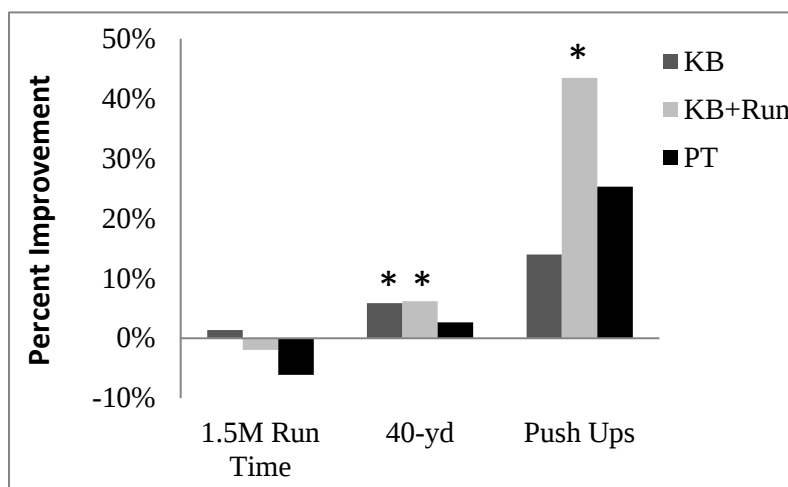


Figure 2. Changes in 1.5-mile run, 40-yard dash, and push-ups.

*Significantly different from baseline within group, $p \leq 0.05$.

Mean heart rate (Table 4) of the KB group was higher than that of the PT group ($p=0.0495$), but there were no differences between KB and KB + run ($p=0.071$) or KB + run and PT ($p=0.94$). Peak heart rate was significantly higher in the KB group compared to the KB + run ($p<0.001$) and the PT group ($p<0.001$). The KB + run group peak heart rate was also significantly higher than the PT group ($p<0.001$).

Table 4. Heart Rate Response to Training

Group	Average Heart Rate	Peak Heart Rate
KB	163.1 (4.2) ^a	182.3 (2.1) ^b
KB + Run	159.5 (4.3)	176.8 (2.1) ^b
Traditional USAF PT	159.7 (3.1)	171.0 (3.2)

Note: Values presented as mean (SD).

^aKB group significantly higher than traditional USAF PT group, $p=0.049$.

^bKB and KB + run groups significantly higher than traditional USAF PT group, $p<0.0001$.

5.0 DISCUSSION/CONCLUSIONS

The results of this pilot study show promise for airmen who are training to gain fitness and who seek alternative forms of training to add variety to their existing routine and improve operationally relevant aspects of fitness. Nontraditional training programs, including KB swing training, could help airmen improve and maintain various USAF PT fitness components that require muscular strength, endurance, speed, and power based on findings from the current study and past research.

This is the first study to investigate the effects of KB swing training on USAF airmen on a combination of fitness parameters such as military fitness assessment performance, strength, speed, power, and agility. In the present study, there were no statistically significant changes in predictive maximal aerobic capacity from the USAF 1.5-mile run; however, the KB training program significantly improved sprinting speed and elicited substantial aerobic stress that produced higher peak heart rates than moderate-intensity running.

Similar to the present study, Thomas et al. [12] reported that KB training can produce the same metabolic stress and greater aerobic fitness responses than brisk treadmill walking at 4% grade and 4 mph. Furthermore, these same investigators surmised that the metabolic responses for KB training met the ACSM Aerobic Fitness Standards to improve aerobic fitness. This is an important finding, especially for airmen who are unable to endure the ballistic strain produced during traditional aerobic exercise modalities, such as running and brisk walking. For airmen who are unable to perform high-impact aerobic exercise, the KB training protocol used in the present study may provide an effective metabolic stimulus to maintain or enhance cardiovascular fitness.

Lake and Lauder [6] reported physiological improvements following 6 weeks of twice weekly 12-minute KB training sessions; however, these authors reported improvements in maximum and explosive strength in 21 healthy men. Although explosive strength and power improvements were not found in the present study, sprinting speed significantly improved in both KB training groups. This is an important finding, especially for airmen who may be required to generate short bursts of speed in both training and battlefield situations. It is postulated that the improvement in the 40-yard dash could be attributed to improvements in

lower body strength, particularly the muscles of the posterior chain (i.e., biceps femoris, gluteus maximus, and erector spinae). A limitation of the current study is the absence of a lower body muscular strength measurement to assess changes in posterior leg strength.

Although KB training did not improve maximal strength and power in the current study, the continuous KB swing training regimen that was chosen by the investigators was similar in volume and duration to previous research in which KB swings elicited an aerobic response [8-13]. In contrast, Otto and colleagues used an explosive KB training regimen that was similar in training volume and rest intervals to Olympic weightlifting (4-6 sets of 4-6 repetitions for 3 exercises) and reported improvements in maximal strength and power following 6 weeks of training in 30 healthy men [9]. Aerobic capacity was not assessed by Otto and colleagues and was not the main objective of their study. Thus, depending on the goals of the individuals, training volume, rest interval time, and training load need to be considered when designing effective KB training programs.

Fung and Shore [13] recommend a KB weight of $\leq 13\%$ of subject's total body mass to induce an aerobic response, following investigation of metabolic cost of 18 minutes of KB exercise, to include KB swings, with 30 seconds of work to recovery intervals in healthy subjects. Additionally, Falatic et al. [10] used KB weights that were 18% of total body mass and reported a 6% improvement in aerobic capacity in women's collegiate soccer players who completed 20 minutes of KB snatches with 15 seconds of work to recovery intervals 3 days a week for 4 weeks. Subjects in the present study used KB weights that were approximately 12-20% of total body mass, which exceeds Fung and Shores' training intensity recommendations for aerobic responses and includes the training intensity used by Falatic et al. All three studies included similar total minutes of work. The subjects used in the present study were not athletes, but they were required to meet specified military fitness standards and were classified as moderately fit according to ACSM standards. Despite similarities in total minutes of work and adequate training intensities when compared with previous studies, improvements in aerobic capacity were not found in the present study.

There were no statistically significant mean percent improvements in 1.5-mile run times in airmen who participated in this pilot study. This may be attributed to the heterogeneous sample and the fact that several subjects did not participate in post-testing due to work schedule restrictions and/or mission requirements, causing unequal amounts of males and females to be included in each group for data analysis. Although there were no statistically significant analyses of variance between groups for any variable before the exercise intervention, the inclusion of males and females in each group resulted in large standard deviations for all variables and may have contributed toward lack of significant findings in both pre- and post-test data.

Interestingly, 10 minutes of KB training sessions provided a higher cardiorespiratory stimulus than 20 minutes of moderate-intensity running. Based on its progressive nature and intensity, KB training may be an effective substitute for running when an airman has time constraints, lacks adequate training facilities/equipment, or is on a medical waiver (469) for no running/walking.

The effects of a KB swing training program on various physiological parameters in trained Air Force men and women were investigated in this study. Based on the results, there were significant improvements in the 40-yard dash in the KB and KB + run groups, but not in the traditional PT group. However, these results should be interpreted with caution based on the limited sample size of subjects who completed pre- and post-testing in the traditional PT group. Nonetheless, the progressive KB exercise program used in this training study shows particular

promise for airmen who wish to maintain 1.5-mile run times, improve sprinting speed, and possibly improve maximal push-ups and body composition. However, these results should again be interpreted with caution due to the particularly low sample size, especially in the USAF traditional training group.

KB swing training is one of the simplest forms of exercise to include into an existing exercise program for military personnel, especially those with limited space and time constraints. Furthermore, a supervised training program such as the one used in this study should be followed to reduce risk of injury and to ensure that subjects progressively increase load in a safe manner.

6.0 RECOMMENDATIONS

For airmen who are unable to perform high-impact aerobic exercise, the KB training protocol used in the present study may provide an effective metabolic stimulus to maintain or enhance cardiovascular fitness, as well as increase operational fitness parameters such as sprinting speed. Future research should be directed toward increasing the sample size within groups and only comparing differences between the KB swing group and the traditional Air Force training group. Future studies should also examine the effectiveness of KB training in a similar group of military personnel to determine its effects of reducing musculoskeletal injury and increasing maximal aerobic capacity. Additional research should also focus on the association of KB training and its effects on reducing pain in the neck, shoulders, and lower back, as reported by Jay and colleagues [14].

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LIST OF ABBREVIATIONS AND ACRONYMS

ACSM	American College of Sports Medicine
AFI	Air Force Instruction
KB	kettlebell
MHR	maximum heart rate
PT	physical training
SD	standard deviation
USAF	U.S. Air Force