

Continuous One-Arm Kettlebell Swing Training on Physiological Parameters in US Air Force Personnel

A Pilot Study

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ABSTRACT

Background: The primary aim of this study was to investigate the effects of continuous one-arm kettlebell (KB) swing training on various US Air Force physical fitness testing components. Thirty trained male ($n = 15$) and female ($n = 15$) US Air Force (USAF) personnel 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. **Methods:** 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, bodyweight, 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 warm-up followed by either (1) 10 minutes of continuous KB swings, (2) 10 minutes of continuous kettlebell 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 rate were recorded for each subject after all sessions. Paired t tests were conducted to detect changes from pretesting to posttesting within each group and analysis of variance was used to compare between-group variability ($p \leq .05$). **Results:** 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 ($p \leq .05$) and KB + run group ($p \leq .05$); however, there were no significant differences in the traditional PT group ($p \leq .05$) or between groups. Maximal push-ups significantly improved in the KB + run group ($p \leq .05$) and trends toward significant improvements in maximal push-ups were found in both the KB ($p = .057$) and traditional PT ($p = .067$) groups. **Conclusions:** 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.

KEYWORDS: kettlebell training; Air Force; 40-yard dash; physical fitness; military personnel

Introduction

The US 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) 36-2905¹ 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 36-2905¹ 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 three to five times weekly.
2. Exercise at an intensity between 60% and 90% of age-adjusted predicted maximal heart rate (MHR = $220 - \text{age}$).
3. Perform 150 to 300 minutes per week of moderate or vigorous activity.
4. Perform a minimum of eight 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 3–5 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 this 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} Additionally, 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 the erector spinae, which are predominantly used in running.⁹ Furthermore, it has been suggested that the effects of KB training programs should be compared with traditional forms of military PT, especially in regard to run performance, muscular strength, and injury prevention.⁴

As reviewed previously, Lake and Lauder⁶ 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 the study group of 21 healthy men. Furthermore, Hulsey et al.⁷ reported average heart rate (HR) values greater than 85% of age-predicted MHR during 10 minutes of KB swing intervals in moderately trained men and women. The high heart-rate response reported by Hulsey et al.⁷ 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 ACSM¹ 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 ($\text{VO}_{2\text{max}}$) during a 12-minute bout of two-handed KB swings in highly fit college-aged men that falls into the ACSM range of 60% to 85% of $\text{VO}_{2\text{max}}$ for cardiorespiratory fitness. Thomas and colleagues¹² reported that combining 10 minutes of continuous KB swings and sumo deadlifts elicited similar metabolic demands as graded treadmill walking. Additionally, Falatic and colleagues¹⁰ 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. We hypothesized that KB training would improve 1.5-mile run times, muscular strength and endurance, speed, power, and agility to a greater extent than traditional USAF PT.

Methods

Thirty active-duty members between the ages of 18 and 40 years were recruited for participation in this study. Subjects were asked to complete a medical screening questionnaire and were cleared by the research medical monitor before participation. Only data from the subjects who completed both pretesting and posttesting were reported. Table 1 lists pretest descriptive data for all three groups. The research protocol was cleared through the Wright Site Institutional Review Board for Human Subjects and subjects were asked to sign an informed consent form before participation.

Each person trained on Monday, Wednesday, and Friday for 10 weeks. Participants received commander approval to replace unit PT with study training sessions and were encouraged to continue to perform normal daily activities throughout the study. Additionally, participants were asked to maintain normal dietary habits and refrain from starting any new physical activities during the study period. All groups were supervised by a trained master's level exercise physiologist. Participants in all three groups wore a HR monitor and reported

Table 1 Subject Pretest Characteristics

Characteristic	KB (n = 7)	KB + Run (n = 6)	Traditional AF PT (n = 7)
Male:Female	5:2	2:4	3:4
Age, years	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)

Data are given as mean (standard deviation). AF, US Air Force; KB, kettlebell; PT, physical training.

peak and average HR values as calculated by the HR monitor after all training sessions.

Experimental Procedures

Subjects participated in 10 weeks of supervised PT and were pretested and posttested to determine the effects of each exercise intervention. Both preintervention and postintervention data collection consisted of 2 separate days of testing with 48 hours of recovery between testing sessions. The first testing session included height, weight, body fat percentage, maximal grip strength, pro agility, vertical jump, and 40-yard dash. The second testing session followed USAF physical fitness testing guidelines in AFI 36-2905 to include waist circumference, 1-minute maximal push-ups, 1-minute maximal sit-ups, and 1.5-mile run. Before each testing session, subjects received instructions and demonstrations on all physical tests.

The 1.5-mile run was assessed on an indoor track, following AFI 36-2905. VO_{2max} was estimated based on subjects' 1.5-mile run times. The following ACSM equation was used to estimate maximal aerobic capacity: VO_{2max} (mL/kg/min) = $3.5 + 483/(\text{time in minutes})$.

After baseline testing, participants were sequentially assigned to one of three training groups using a block design based on the primary outcome variable (i.e., 1.5-mile run time) to ensure an even distribution of pretest run times per group. Participants in the KB group completed a dynamic warm-up for 10 minutes, followed by 10 minutes of KB swings (five sets of 2 minutes with 30 seconds' rest between) and a 5-minute cool-down consisting of light cycling, jogging, or walking. Participants in the KB + run group completed a dynamic warm-up for 10 minutes, then 10 minutes of KB swings, immediately followed by 10 minutes of continuous high-intensity running (>85% of age-predicted HR_{max}) and a 5-minute cooldown. Participants assigned to the traditional USAF training group trained in accordance with AFI 36-2905. Subjects engaged in 20–30 minutes of running and calisthenics (i.e., push-ups, sit-ups). This included a dynamic warm-up for 10 minutes, 20 minutes of running

in a prescribed target HR training zone (60% to 85% HR_{max}), and calisthenics including 3 × 1 minute of push-ups and 3 × 1 minute of sit-ups, with 30 seconds rest in between sets, followed by a 5-minute cool-down. Table 2 lists the exercise session breakdown for each group. Maximum HR was calculated for the KB + run and the traditional PT groups using the following ACSM formula: $MHR = 206.9 - (\text{age in years} \times 0.67)$.

Table 2 Exercise Session Breakdown

KB only	KB + High-Intensity Run	Traditional PT
Dynamic warm-up (10 min)	Dynamic warm-up (10 min)	Dynamic warm-up (10 min)
KB swings (10 min)	KB swings (10 min) Run > 85% HR_{max} (10 min)	Run at 60% to 85% HR_{max} (20 min) 3 × 1-min push-ups 3 × 1-min sit-ups
Cool down (5 min)	Cool down (5 min)	Cool down (5 min)

HR_{max} , maximum heart rate; KB, kettlebell; min, minute; PT, physical training.

Before the study, investigators received training and instructional DVDs on continuous one-arm KB swing technique from World Kettlebell Club founder and trainer, Valery Federenko (Figure 1A–1D). Subjects in the KB and KB + run groups were instructed to follow the one-arm swing technique, switching arms every five repetitions. The first 2 weeks of training consisted of instructional sessions and progressed in duration of KB swings from 4 × 1 minute with 1 minute of rest between sets to 5 × 2 minutes with 30 seconds' rest between sets by the end of week 2. The duration of KB training remained at 5 × 2 minutes for weeks 3–10.

KB weights were selected based on proper technique execution and were progressively increased based on participants' technique and perceived effort throughout the study. Male subjects in the KB group and the KB + run group began the study using 8kg to 12kg KBs and finished the study using 12kg to 18kg KBs. Female subjects began the study using 6kg to 8kg KBs and progressed to 10kg to 14kg KBs the final week of the study.

Statistical Analyses

A repeated measures design was used to detect differences between pretraining and posttraining scores. Analysis of variance (*F* test) was used to compare the variability between the groups. Post hoc analysis using *F* tests was performed when significant interactions were observed. The statistical analyses were performed using the Statistical Package for Social Sciences version 20.0 (IBM Corp., <https://www.ibm.com>) with an α level set at $p \leq .05$.

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



(A) Starting position, front view.



(B) Starting position, side view.



(C) Ending position, front view.



(D) Ending position, side view.

Results

Before training, 30 participants were sequentially assigned to one of three training groups based on their 1.5-mile run times. Each group consisted of 10 subjects (five men and five women). After 10 weeks of training, 20 participants completed the study; the attrition rate was 33.3%. Only data from the subjects who completed both pretesting and post-testing were included in the statistical analysis. There were no baseline significant differences between groups in any of the pretest variables. Table 3 lists all three study groups' before and after anthropometric and physical performance data.

Three airmen in the traditional PT group were unable to complete day 2 of posttesting (1.5-mile run, push-ups, and sit-ups) because of 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 ($p > .05$). The 40-yard dash significantly improved within the KB swing group ($p \leq .05$) and KB + run group ($p \leq .05$). There were no significant changes noted in the traditional PT group ($p > .05$) or between groups for the 40-yard dash. Only the KB + run significantly increased the number of 1-minute maximal push-ups ($p \leq .05$).

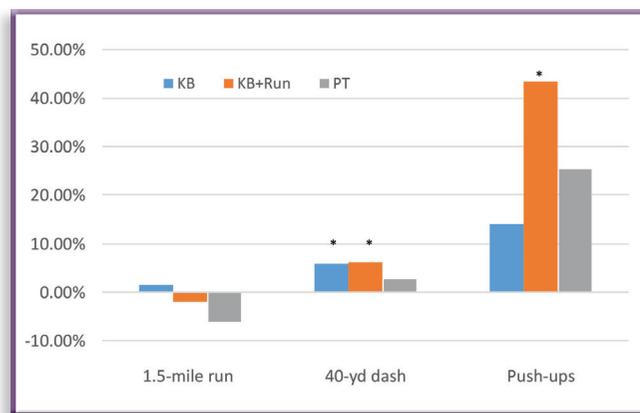
Mean HR (Table 4) of the KB group was higher than that of the PT group ($p = .0495$), but there were no differences between KB and KB + run ($p = .071$) or KB + run and PT ($p = .94$). Peak HR was significantly higher

Table 3 Anthropomorphic and Performance Comparisons between Training Groups

Item	KB (n = 7)		KB + 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 (15.3)	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 ^b	40.6 (8.0)	46.7 (13.4)	24.0 (17.3)	31.7 (20.8) ^a	37.8 (11.3) ^c	47.2 (16.8) ^c
Max sit-ups ^b	47.1 (14.9)	50.3 (9.0)	43.8 (13.8)	44.0 (14.1)	44.7 (8.9) ^d	52.5 (4.7) ^d
1.5-mile run ^e	12:13 (1:23)	12:01 (1:14)	12:55 (1:53)	13:10 (2:05)	13:34 (1:39) ^d	14:27 (3:05) ^d
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, seconds	5.5 (0.4)	5.5 (0.4)	6.2 (0.9)	6.1 (1.0)	5.6 (0.4) ^f	5.7 (0.5) ^f
Vertical jump, cm	39.6 (9.4)	40.9 (10.7)	36.3 (14.7)	37.1 (14.5)	37.3 (8.1)	37.3 (9.9) ^f
40-yard dash, seconds	6.2 (1.0)	5.8 (0.9) ^a	7.0 (1.2)	6.5 (1.0) ^a	6.2 (0.6) ^f	6.0 (0.5) ^f

Data given as mean (standard deviation). AF, Air Force; max, maximum; KB, kettlebell; PT, physical training. ^aSignificantly different from pretest ($p \leq .05$). ^bNumber per minute. ^c $n = 5$. ^d $n = 4$. ^eminutes:seconds. ^f $n = 6$.

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



*Significantly different from baseline within group, $p \leq .05$.

in the KB group compared with the KB + run ($p < .001$) and the PT groups ($p < .001$). The KB + run group peak HR was also significantly higher than that of the PT group ($p < .001$).

Discussion

To our knowledge, this is the first study to investigate the effects of continuous KB swing training in USAF airmen on a combination of fitness parameters such as military fitness assessment performance, strength, speed, power, and agility. There were no statistically significant changes in predictive maximal aerobic capacity from the USAF 1.5-mile run in any group. Both KB groups performed minimal amounts of running (i.e., the KB + run group ran for 10 minutes three times per week and the KB group did not run) yet still maintained 1.5 miles run times and achieved statistically significant improvements in sprinting speed. Furthermore, the KB + run group significantly improved 1-minute maximal push-ups, and there was a trend in the KB group for maximal

Table 4 HR Response to Training

Group	Mean HR	Peak HR
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)

Data given as mean (standard deviation). HR, heart rate; KB, kettlebell; PT, physical training; USAF, US Air Force.

^aKB group mean HR was significantly higher than that of the traditional USAF PT group ($p = .049$).

^bKB and KB + run groups' HRs were significantly higher than that of the traditional USAF PT group ($p < .0001$).

push-up improvement ($p = .058$) even though these two groups did not perform push-ups. Interestingly, the KB + run group did not perform any push-ups but had a higher percent improvement in maximal push-ups (31.9%) than the traditional PT group (24.9%), who performed push-ups three times per week for 10 weeks.

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. However, these results should be interpreted with caution because of the particularly small sample size, and the uneven final distribution of men to women across groups because of attrition.

The KB swing regimen in both KB groups elicited a substantial aerobic and anaerobic stress that produced higher peak HRs than moderate-intensity running. Similar to this study, Thomas et al.¹² reported that continuous 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 finding

is particularly important 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, continuous KB training may provide an effective metabolic stimulus to maintain or enhance cardiovascular fitness.

Lake and Lauder⁶ reported physiologic improvements after 6 weeks of twice-weekly 12-minute KB training sessions; however, these authors reported improvements in maximum and explosive strength and no data were reported for aerobic measures. Additionally, Otto and colleagues⁹ used an explosive KB training regimen that was similar in training volume and rest intervals to Olympic weightlifting (four to six sets of four to six repetitions for three exercises) and reported improvements in maximal strength and power after 6 weeks of training in 30 healthy men. Aerobic capacity was not assessed by Otto and colleagues and was not the main objective of their study. Although explosive strength and power improvements were not found in our 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 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 this study is the absence of a lower-body muscular strength measurement to assess changes in posterior leg strength.

Depending on the goals of the training program, variables such as training volume, rest interval time, and training load need to be considered when designing effective KB training programs. Because 1.5 mile run time was the primary outcome variable in this study, we chose a KB swing regimen that was similar in volume and duration to previous research in which an aerobic response was elicited.⁸⁻¹³ Fung and Shore¹³ recommended a KB weight of $\leq 13\%$ of the subject's total body mass to induce an aerobic response, after investigation of the 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% to 20% of total body mass, which exceeds Fung and Shores'¹³ training intensity recommendations for aerobic responses and includes the training intensity used by Falatic et al.¹⁰ All three studies included similar total minutes of work.

Additionally, the participants in our 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 compared with previous studies, there were no statistically significant mean percent improvements in predicted aerobic capacity in airmen who participated in this pilot study.

The heterogeneous sample in this study and the fact that several subjects did not participate in posttesting because of work schedule restrictions and/or mission requirements caused an unequal number of men and women to be included in each group for data analysis. Although there were no statistically significant differences in the analyses of variance between groups for any variable before the exercise intervention, the inclusion of men and women in each group resulted in large standard deviations for all variables that may have contributed toward lack of significant findings in both pretest and posttest data.

Conclusion

Based on its progressive nature and intensity, KB training may be an effective substitute for traditional PT when an airman has time constraints, lacks adequate training facilities or equipment, seeks a high-intensity/low-impact alternative to running, or is on a medical waiver (469) for no running/walking. KB swing training is a one of the simplest forms of exercise to include in an existing exercise program for military personnel, especially those with limited space and time constraints. To ensure that subjects safely progress load and execute correct technique, supervision of KB training is recommended to reduce injury risk and maximize results. The progressive KB exercise program used in this training study shows particular promise for airmen who wish to maintain 1.5-mile run times, and improve sprinting speed and maximal push-ups. However, these results should be interpreted with caution because of the particularly small sample size, and the uneven ratio of men to women across groups.

Future studies should examine the effectiveness of KB training in a larger group of military personnel to determine its effects on reducing musculoskeletal injury and increasing maximal aerobic capacity and operational fitness measures. 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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Disclaimer

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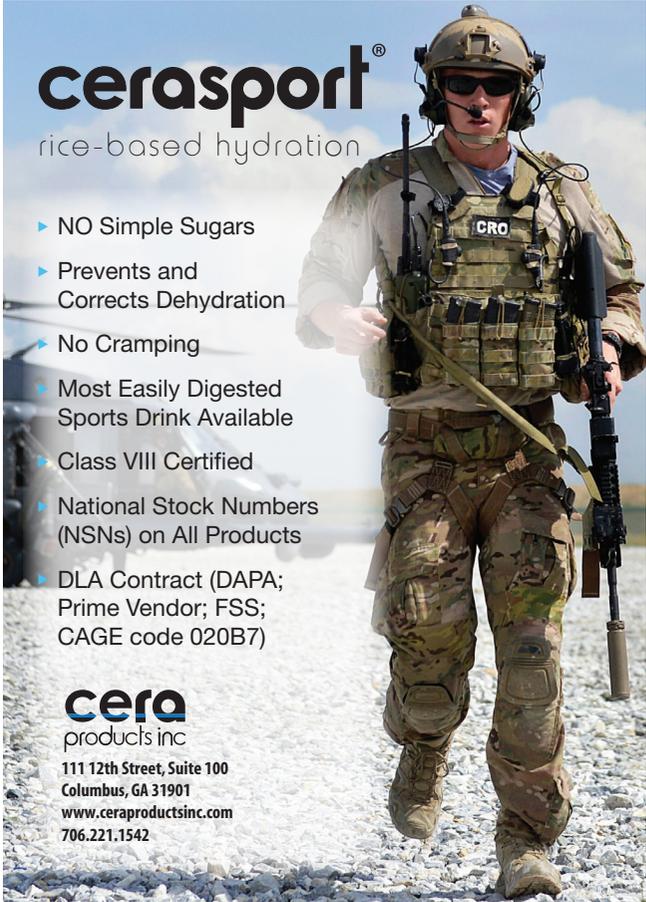
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