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Effects of High Intensity and Sprint Interval Training Frequency
on 1.5 Mile Run Times in Air Force ROTC Cadets

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Running head: Frequency of High Intensity Interval Training

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ABSTRACT

The effects of varying high intensity interval training (HIIT) and sprint interval training (SIT) frequency on 1.5 mile (2.4km) run performance in Air Force ROTC cadets were studied. Twenty-seven cadets (21.6 ± 2.8 years) were stratified then randomly assigned to 3 groups: a high frequency group (HF) that performed HIIT/SIT 3x week, a low frequency group (LF) that performed HIIT/SIT 2x week, and a continuous training group (CG) that performed moderate intensity training 3x week. HIIT workouts consisted of 4 x 3 min intervals at 90-100% of velocity at maximal oxygen consumption (vVO2 max) with 4 min of active recovery between sets. SIT workouts consisted of 4 x 30s all out sprints with 4 min active recovery between sets. Baseline 1.5 mile run performance was measured, then retested at 6 and 10 weeks. At the end of 6 weeks, all groups significantly improved in mean 1.5 mile run time (LF, 7.3% ± 4.2, p<0.001; HF, 9.7% ± 3.5, p<0.001; CG, 8.7% ± 4.8, p<0.001). No significant differences between groups were found at any point in time (p>0.05). Additional workouts beyond the 6-week point yielded no significant gains in run performance for any group. In conclusion, 2 days per week of combined HIIT/SIT training was as effective at improving 1.5 mile run performance as either 3 days/week of HIIT/SIT or continuous training, and the majority of initial performance gains from HIIT were achieved within the first 6 weeks of training.

Keywords: velocity at VO2max, continuous training, military, anaerobic exercise
INTRODUCTION

High-intensity interval training (HIIT) is a term used to describe repeated bouts of exercise at a maximal, or near maximal level, interspersed with recovery periods. Over several decades, a large body of research has shown that HIIT is capable of eliciting physiological adaptations similar to lower intensity continuous training (1,19,30), but may do so with a smaller training volume (9,18,26). In recent years, HIIT has become an appealing training option within the military due to its potential to decrease overuse injuries (7,21,22,23). However a lack of performance-oriented HIIT studies conducted on military populations and unclear programming guidelines for its implementation pose a challenge for military trainers trying to incorporate it into a comprehensive fitness program. As HIIT’s popularity expands outside the world of collegiate and professional sports, it is important to further investigate its relevance to the unique fitness demands of non-athlete populations, such as the military.

In order to more effectively integrate HIIT into a military training regimen, two important gaps in the literature need to be addressed. First, building successful HIIT protocols requires knowledge of how to manipulate complex combinations of acute and non-acute training variables (6,25). Previous HIIT studies have focused mainly on acute variables such as interval and rest intensities (3,5,13,31) and interval and rest lengths (2,15,28). Far less attention has been given to non-acute variables, such as the optimal training frequency for HIIT. While many studies have focused on the effects of frequency in endurance training, our literature review found only two studies that investigated the impact of weekly HIIT frequency as the independent variable, while holding other training variables constant (11,20). Hatle et al. (20) compared a 4x/week HIIT frequency to an 8x/week frequency that used treadmill running as the exercise
modality. They found that although improvements in VO$_2$ max were delayed in the high frequency group, neither group’s mean improvement was superior (between-group difference, \( p=0.319 \)). Dalleck et al. (11) explored the effects of SIT frequency at much lower levels on lactate threshold (LT) and demonstrated that improvements in LT could be achieved with only 1-2 days/week of SIT. However, there was a dose-response relationship, with the 2x/week frequency eliciting significantly larger effects on LT than the 1x/week protocol (\( p<0.05 \)). From a practical perspective, most military members would be unlikely to train 8x/week, and the dose-response relationship for LT suggests that 1x/week of stand-alone SIT may not be an ideal level either. Research that compared the lower ends of effective frequency (for example, 2x/week vs 3x/week) has not been conducted but may be more useful for establishing programming guidelines.

Second, the majority of studies, to date, have measured physiological changes elicited by HIIT, especially improvements in VO$_2$ max (1,19), but have not addressed the extent to which these changes translate into actual performance gains. This is problematic since VO$_2$ max increases do not necessarily correspond with performance improvement (12). Military fitness requirements focus heavily on running ability, usually at mid-distances of 1.5-3 miles (2.4-4.8 km), but only eight studies were discovered that measured actual performance gains on mid-distance running events in any population (2,13,14,15,26,29,31,32) with four of the eight using training procedures that would be impractical to follow in a military field setting (2,15,31,32). The generalizability of these studies to a military population is also uncertain since they used untrained, recreationally active, and well-trained athletes as their subjects. The military population is unique due to its combat-related training and physical requirements that focus on
both muscular strength and cardiovascular fitness, making it unclear where they would fall within the categories of subjects typically tested.

Although other military branches have published limited HIIT research relating to injury prevention (7,21,22,23), the Air Force has no HIIT-related studies conducted on its population. Additionally, the Air Force uses a 1.5 mile run as its official measure of cardiovascular fitness, a distance which, to our knowledge, has not been studied in any HIIT research. Therefore, the primary aim of the present study was to measure the effects of varying HIIT frequency in an Air Force population on 1.5 mile running performance. We hypothesized that varying the weekly frequency of HIIT between 2x and 3x per week would not significantly affect run performance. Furthermore, we hypothesized that participants performing HIIT would show greater improvement on 1.5 mile run times than a continuous training group which performed moderate intensity cardiovascular training. Although not the primary focus of the present study, another aim was to establish a reasonable estimate for running improvement over the course of 15 workouts in an Air Force population using HIIT.

**METHODS**

**Experimental Approach to the Problem**

While the variety of HIIT designs is almost limitless, two approaches have been frequently repeated in studies with successful outcomes and were selected for use in the present study. First is a sprint interval training (SIT) protocol employing 30s sprints at maximal effort followed by 4 min recovery periods. Previous studies have investigated this protocol for varying lengths of time, to include 2 weeks (8,18), 4 weeks (3), 6 weeks (26) and 8 weeks (29) all with training
frequencies of 2-3 x week. A second approach uses velocity at VO$_2$ max ($vVO_2$ max), which is the minimum running velocity required in order to achieve VO$_2$ max during exercise. Previous studies have used $vVO_2$ max as a means of individualizing the intensity to the athlete and typically employ protocols that run participants at speeds between 80-120% $vVO_2$ max (2,13,15,31).

Participants were recruited from the University Air Force ROTC detachment. Knowing the cadets would be involved in free-living physical activity related to school and ROTC outside the study, each participant’s free-living activity data were gathered and controlled for by stratifying cadets prior to randomization. The collected data included type, frequency, time, and intensity of activities in which the cadets engaged apart from their regularly scheduled unit fitness. Cardiovascular-based activities that could affect running performance were isolated, and the total weekly minutes of free-living cardiovascular activity beyond ROTC-mandated training for each participant were calculated. Each participant was then stratified based on their weighted activity level into one of three groups: Low (<20 min/wk), Moderate (21 to 50 min/wk), and High (>50 min/wk). Once stratified by activity level, participants were randomly assigned to one of the three intervention groups consisting of a high frequency group (HF), low frequency group (LF) or continuous training group (CG). Weekly activity reports were collected from each participant over the course of the study in order to capture any changes from baseline.

The HF performed 15 interval workouts at a rate of 3 days/week. The LF also performed 15 interval workouts, but at a frequency of 2 days/week. The CG trained 3 days/week throughout the course of the study. All participants were retested at the 6-week mark (i.e., at completion of
the HF’s 15 workouts). Following the 6-week retest, the HF entered a decay-rate phase where it trained 3 days/week for an additional 3 weeks, following the same training protocol as the CG. The LF continued their original training regimen until they had completed the remainder of their 15 workouts and retested on week 10. By design, the HF decay rate assessment coincided with the LF’s 10-week reassessment. Following completion of its HIIT regimen, the LF then moved into a decay rate phase, training for 3 weeks using the same protocols as the CG. The LF performed its decay rate assessment on week 13. It should be noted that minor interruptions to the training schedule occurred due to a federal holiday, retests, spring break, and an ROTC-related training event. These interruptions explain why the LF required nine weeks to complete 15 training sessions instead of only eight. An overview of the training schedule is shown in figure 1.

[Place Figure 1 about here]

Because Air Force fitness requirements emphasize upper body and core strength as well as cardiovascular fitness, all participants performed a 15-20 min resistance training (RT) program 3 days/week to ensure muscular strength and endurance were maintained. The regimen was standardized across all groups and was accomplished on non-consecutive days of the week either immediately before or after the groups’ cardiovascular workouts. In the case of the LF group which only performed HIIT 2x/week, they performed 1 day/week of RT as a stand-alone workout that was not coupled with HIIT. The order of the cardiovascular and RT workouts alternated weekly so that each group had equal training sessions in which RT was performed right before cardio training, and vice versa.
Subjects

Forty-seven University Air Force ROTC cadets (8 female, 39 male; 21.6 ± 2.8 years) were recruited. Baseline data were collected on height, mass, BMI, abdominal circumference, 1-min timed pushups and sit-ups, and 1.5 mile run. Each component was administered in accordance with current Air Force regulations as outlined in Air Force Instruction 36-2905 (34). All participants were briefed in detail on the potential risks, benefits, and procedures involved with the study and gave written informed consent prior to beginning the intervention. The study was conducted with approval from the Utah State University IRB.

Throughout the 14-week intervention, 20 of the 47 participants were removed from the study. Attrition was due to a variety of reasons including injuries (6 participants), failure to attend minimum required workout sessions or retests (11 participants), and students’ personal decisions to withdraw from the ROTC program that were unrelated to the present study (3 participants). The minimum number of required workouts was set at 12 for all groups. Any participant who missed more than three workouts due to absence or injury or who failed to attend performance tests on the scheduled day was removed from the study. Injury reports were collected weekly. An injury was defined as any event that interfered with a participant’s ability to complete their scheduled workout due to pain or discomfort. Throughout the course of the study, seven injuries were reported during HIIT or continuous training workouts and ten injuries acquired during free-living activities. Of the six participants who were removed from the study due to injuries, three reported minor lower extremity issues (2 cases of shin splints and 1 case of knee pain), one injury was acquired during warm-up and resulted in low back pain, and two injuries were
sustained outside the study during free-living activity. When compared with other HIIT/SIT studies that performed mid-distance running tests, it is unclear whether this attrition rate is abnormal, since attrition was not reported in any of the research we reviewed (2,13,14,15,26,29,31,32). Subject height, mass, abdominal circumference, BMI, maximum 1-min pushups and sit-ups and average free-living activity data are shown in Table 1.

[Place Table 1 about here]

**Procedures**

During each training session, the HF and LF performed either a SIT or HIIT workout for a total of seven SIT workouts and eight longer duration but lower intensity HIIT workouts. Participants alternated between these two types of workouts so they were spread evenly over the 15 sessions. All interval workouts were performed on an indoor track with an inside lane which measured 200.8m. Sprint interval workouts consisted of 4 x 30-sec all-out effort sprints followed by 4-min recovery periods at a light jog. The HIIT sessions consisted of 4 x 3-min intervals at 90-100% vVO₂ max with 4-min recovery intervals at a light jog. Participants in the HF and LF groups started the study at their 90% vVO₂ max level and then increased by 5% increments once they were able to complete all four intervals successfully at that speed. If a participant accomplished a HIIT workout at the 100% vVO₂ max level, they continued to increase the intensity by 5% of their 100% vVO₂ max speed until they reached the point at which they could not complete an entire workout at the new intensity level. The CG’s training consisted of jogging and/or machine-based cross training performed at an RPE level of 11-14 on the standard Borg scale. Continuous training group participants completed two running-based workouts weekly and one
cross training workout in which they could select a cardio machine of their choice (elliptical, stationary bike, rowing machine, or stair climber). The CG workouts were matched with the HF and LF workouts for time, lasting 18 min on SIT days and 28 minutes on HIIT days. A 5 to 7-min warm up session that included a light jog and dynamic stretching of the main muscle groups was performed by all groups at the beginning of each session. Static stretching of main muscle groups was accomplished at the end of workouts with participants being encouraged to hold each stretch for 30 seconds.

In order to establish an estimated vVO$_2$ max for HIIT sessions, a 5-min vVO$_2$ max field test was performed prior to beginning the study. The field test was validated by two previous studies (4,10), and consisted of a 7-min warmup followed by a 5-min run for maximal distance. Each subject’s distance run was then converted into a meters/min speed which corresponded to their estimated 100% vVO$_2$ max speed. This meters/min speed was multiplied by 3 minutes to establish the distance the runner would need to cover in order to meet their 100% vVO$_2$ max intensity during each repetition of the 3-min HIIT workout. Multiplying that distance by 0.9 and 0.95 provided the 90% and 95% intensity range, respectively. Prior to beginning the training, each runner was given a diagram of the track with the total distance (i.e., number of laps) they needed to complete in order to meet their personal 90%, 95%, and 100% vVO$_2$ max levels during their HIIT workouts. Each participant practiced completing a set of HIIT intervals prior to the start of the study in order to ensure they were familiar with the protocol and could identify their vVO$_2$ max goal distances at each intensity level.
Statistical Analyses

Due to the attrition rate, an independent sample t-test was performed to identify any significant differences in mean baseline data between participants who dropped out and those who completed the study. All drop-out participants were grouped and compared to all participants who completed the study. A Chi-square test was used to ensure the expected distribution of free-living activity levels was still approximately equal across the three intervention groups following attrition. Although HIIT-related injury rates were not a primary focus of this study, the number of total reported injuries (i.e., both study-related and free-living activity acquired injuries) was higher than anticipated. Injury data was collected weekly, allowing for a logistic regression analysis to be performed using injuries as the dependent variable and intervention group as the independent variable to determine if one group was more likely to sustain injuries than another.

A repeated measures ANOVA was performed to identify statistically significant differences between varying lengths of time (i.e., baseline, 6 weeks, 10 weeks) on 1.5 mile run performance while controlling for intervention group. A second repeated measures ANOVA was performed to identify significant differences between the effects of the number of training sessions completed on 1.5 mile run while controlling for intervention group. Combined, these two tests allowed a comparison of the effects of elapsed time on run performance with the effects of completed workouts to see if one was more influential. Pairwise comparisons were performed on significant interactions, then followed up with a Bonferroni post-hoc test. The significance level for all tests was set at $\alpha = 0.05$. The standardized difference between means (effect size) was measured using Cohen’s $d$ with threshold values of $>0.2$ (small), $>0.5$ (moderate), $>0.8$
A 95% confidence interval was calculated for significant changes in run times. Statistical analysis was accomplished using IBM SPSS software (version 22).

**RESULTS**

The independent samples t-test revealed no significant differences in mean baseline scores on any measure between those who dropped out and those who completed the study (p > 0.05). The overall non-significance of this test lent validity to the results of the study, in spite of the attrition. The logistic regression analysis of injuries showed that a likelihood ratio test of the full model against a constant-only model was not statistically significant and that group assignment did not correlate with injuries, $\chi^2 = 0.670$, $p = 0.715$. Similarly, no relationship between free-living activity and group assignment was found, $\chi^2 = 2.21$, $p = 0.697$. This provided evidence that the expected distribution of free-living activity levels across the three groups was still approximately equal at the conclusion of the study and that subsequent analysis would be valid.

The mixed model ANOVA was performed to measure the effects of time on run, and a Greenhouse-Geisser correction was employed due to lack of sphericity (Mauchly’s W = 0.153, approximate $\chi^2 = 15.348$, $p < 0.001$). The interaction between group and time was found to be non-significant ($p = 0.455$) indicating that all groups had a similar pattern of improvement over time. Within-group improvement over time was significant, and the average decrease in run time for all participants was 1.00 min (SE = 0.10 min) after 6 weeks, $p < 0.001$ (95% CI 0.739, 1.267). Effect size of the within-group improvement ranged from moderate in the LF group (Cohen’s d = 0.54) to large in the HF (Cohen’s d = 0.88) and CG (Cohen’s d = 0.86). However, over the subsequent 4 weeks of training (i.e., weeks 7-10), no significant additional improvement
was seen, although the initial improvement was maintained (mean change = -0.10 min, p = 0.414). A similar analysis was performed using the number of sessions completed instead of elapsed time. The results were robust and nearly identical to those cited above for time. Mean 1.5 mile run averages for all 3 groups over time are displayed in Figure 2. Mean percent improvement as a function of both time and session completion were also calculated for each group and are displayed in Table 2.

DISCUSSION

The results of the present study supported our primary hypothesis that performing HIIT 2x/week on non-consecutive days would be as effective at improving 1.5 mile run times in an Air Force population as HIIT performed 3x/week. Although the LF only accomplished 11 training sessions at the 6-week retest compared to the HF’s 15 sessions, there was no significant difference between their mean 1.5 mile run times. Moreover, a comparison of LF to HF at the 10-week point showed that mean run times were similar, despite the fact that the LF had completed only 15 total sessions compared to the HF’s 21 sessions. These findings imply that elapsed time between sessions was a more significant factor in performance improvement than the total number of sessions completed. The results of Hatle et al. (20) corroborate this finding. Their high frequency group trained 8x/week for three weeks, but achieved no significant improvements in VO2max at the end of their training period. The first increase did not occur until one week
into detraining, and their highest increase occurred five weeks into detraining. The authors hypothesized that waiting until the body completes its adaptation/recovery phase and returns to homeostasis before restressing it is critical to achieving a supercompensation that boosts the athlete’s performance above baseline levels (20). Thus, in terms of efficiency, performing the fewest number of training sessions needed by introducing them at such a frequency that they restress the body immediately after the previous adaptation has completed would appear to optimize outcomes.

Air Force guidelines for exercise frequency admonish Airmen to “accomplish moderately intense aerobic activity 30 minutes a day, five days a week or vigorously intense aerobic activity 20 minutes to 25 minutes a day, 3 days a week…” (34). These guidelines are based primarily on the 1998 ACSM position paper which recommended 3-5 days/week of training to “develop and maintain cardiorespiratory fitness” (27). However, our results call into question whether a minimum of 3 days/week of “vigorously intense aerobic activity” is necessary to develop and maintain cardiovascular fitness. The most recent ACSM guidelines avoid a minimum weekly frequency recommendation and instead recognize that there is a complex interaction between acute and non-acute variables that is not fully understood. The 2011 position paper states, “Additional randomized controlled trials and meta-analyses are needed to explore the threshold phenomenon in populations of varying fitness levels and exercise training regimens because of the interactive effects of exercise volume, intensity, duration, and frequency and individual variability of response” (17). The present study suggests that the threshold phenomenon exists, and that in a moderately trained Air Force ROTC population, two non-consecutive days of HIIT/SIT is sufficient to reach that threshold. That said, the trend in percent improvement at the
6-week mark between groups appeared to favor the HF (9.7% ± 3.5) and CG (8.7% ± 4.8) compared to the LF (7.3% ± 4.2) even though it did not reach statistical significance. It is unclear whether this trend and the larger effect sizes seen in the HF and CG were due to the higher frequency of training or a result of the LF group starting at a higher overall baseline fitness level, leading to a more attenuated response to training.

Our hypothesis that HIIT would be more effective at improving 1.5 mile run performance than matched amounts of continuous training was incorrect. Comparisons of the HF and CG showed there were no statistically significant differences in mean run performance when measured in terms of either elapsed training time or session completion. These findings contradict the widely held notion that HIIT is a more time-efficient training strategy than continuous training. While recent research has demonstrated that large volumes of endurance training (ET) yield similar physiological adaptations to much smaller volumes of HIIT, these studies did not use matched training volumes, either in terms of workload or time (9,18,26). Without equally matching the workouts, meaningful comparisons about efficiency cannot be made. Another questionable practice when comparing HIIT and ET efficiency is to only count time spent during the actual interval, not the rest interval. However, even passive recovery phases following an intense interval can be much more strenuous than low-intensity continuous training. Gist et al. (19) noted this oversight in their meta-analysis of 16 SIT studies that compared the effects of SIT to ET or no exercise. They concluded that SIT did not elicit statistically significant improvements in \( VO_2 \)\text{max} compared to ET (\( p = 0.72 \)), and questioned the reported time savings of SIT compared to ET which some authors claimed, because their studies failed to include the rest intervals in the total exercise time (19). This tendency for recent studies to make comparisons
between HIIT and continuous training without matching workout time or including recovery intervals as part of the exercise may warrant a re-evaluation of the increasingly popular notion that HIIT is a more efficient form of exercise.

Our study also sheds light on how long a HIIT regimen needs to be continued in order to generate significant results in running improvement. Since our participants did not show further improvement after the first 6 weeks of training, regardless of what protocol they followed (high vs moderate intensity) or how frequently they exercised (2x vs 3x/week), it appears that 6 weeks of HIIT/SIT performed at a frequency of 2x/week could be an upper limit for initial gains. Other studies have shown significant run improvement in as few as 4 weeks using frequencies ranging from 2-3x/week (13,14,31,32). The results of Hatle et al. (20) also confirm that significant increases in VO₂max can occur in as few as 4 weeks, however, since they did not retest VO₂max again until the 8-week point and did not make statistical comparisons between the 4-week and 8-week results, it is difficult to determine from their study what the upper time limit of significant improvement was in their moderate frequency group (20). Taken together, these data do not suggest that long-term training is not beneficial, but only that large initial gains in performance can be achieved by moderately trained athletes in as little as 4 weeks and appear to taper off after approximately 6-8 weeks of HIIT.

Our findings are also unique when compared to other studies that measured mid-distance running improvement from HIIT/SIT. Previous studies have reported run improvements in trained athletes of 1-2% (2,13), 2-3% (31,32) and 4.4% (29) following 2x/week HIIT protocols. Studies investigating HIIT’s effects on untrained or recreationally active subjects training 3-4x/week
found 3.4% (15), 4.5% (14) 5.6% (26), 5.8% (29), and 7.3% (15) improvements on mid-distance runs. Our LF participants experienced a 7.3% ± 4.2 improvement training 2x/week, suggesting that combining HIIT/SIT into an integrated regimen is an effective training protocol for mid-distance runs, even when performed at a low weekly frequency. To our knowledge, the present study is the first to combine both HIIT and SIT into a single regimen, although previous research has suggested that SIT stimulates adaptations via unique routes (16,33) and that HIIT and SIT combined could have a synergistic effect (6,24).

Finally, our study found that HIIT was not more likely to result in injury than lower intensity continuous training. As mentioned earlier, the military’s research on HIIT has focused largely on injury prevention versus performance improvement. One reason for this focus is that during basic training, roughly 25% of males and 50% of females incur training injuries with approximately 60%–80% of these classified as “overuse injuries” to the lower extremities (7). Volume overload (especially in the form of long-distance running) has been shown to be a major contributor to such injuries, and interventions have demonstrated that replacing high mileage runs with low mileage HIIT during boot camp can cut lower extremity overuse injuries profoundly while not diminishing fitness gains (21,22). The Army, in particular, has already incorporated HIIT into experimental training protocols (23) and The Joint Services Physical Training Injury Prevention Working Group recommended interval training as a viable option for reducing overtraining injuries associated with repetitive strain on the lower extremities (7). Of the reported HIIT-related injuries acquired throughout the present study in both intervention groups, the majority were mild cases of shin-splints that resolved after a short period of rest from running. These injuries may have been associated with the type of indoor track used for training,
since the surface was painted concrete as opposed to softer rubberized material used for many outdoor tracks. The inside lanes where most interval training was conducted measured approximately 200m and created more torque on the lower extremities than typical 400m outdoor tracks due to the curvature of the running lanes. Despite these two environmental factors, it is noteworthy that the overall number and severity of injuries acquired from non-study free-living activity exceeded that acquired from the HIIT and continuous training regimens combined. Based on these data, there is no evidence that HIIT posed a higher risk for injury than steady state running and cross-training, and certainly not more than common free-living activities in which the participants were routinely engaged.

**PRACTICAL APPLICATIONS**

Like other segments of society, Air Force members often struggle to meet the recommended guidelines for weekly physical activity. For unit fitness trainers that find it difficult to get their Airmen into the gym 3-5 days/week, the present study indicates that a combined HIIT/SIT protocol performed 2 days/week is a viable alternative that can still improve cardiorespiratory function while being practical to implement in a field setting. We found the largest performance gains likely occur within the first 6 weeks of beginning HIIT and therefore, to the extent possible, implementation should be timed so that running performance peaks just prior to an Airman’s fitness test. Although individual responses to HIIT can vary, our study suggests that active Airmen who are relatively fit and have a healthy BMI could expect a modest improvement of approximately 7% on a 1.5 mile run time after six weeks of HIIT/SIT performed at a frequency of 2 days/week.
REFERENCES


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The authors have no conflict of interest relevant to the content of this article. The contents of the present study do not constitute endorsement by the authors or the NSCA. The views expressed in this article are those of the author and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the U.S. Government.
FIGURE LEGENDS

**Figure 1.** Training schedule.

**Figure 2.** Changes in 1.5 mile run performance over time. Data points and error bars represent mean ± SE. Solid line = control group (CG); short dashed line = high frequency group (HF); long dashed line = low frequency group (LF).
Table 1. Descriptive baseline data (mean ± SD).

<table>
<thead>
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<th>Low Frequency (n = 8)</th>
<th>High Frequency (n = 9)</th>
<th>Continuous Training (n = 10)</th>
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<tr>
<td><strong>Height (cm)</strong></td>
<td>173.9 ± 9.7</td>
<td>177.5 ± 10.4</td>
<td>178.6 ± 8.4</td>
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<td><strong>Mass (kg)</strong></td>
<td>67.7 ± 8.4</td>
<td>74.5 ± 15.0</td>
<td>79.6 ± 13.1</td>
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<tr>
<td><strong>Abd Circum (cm)</strong></td>
<td>79.5 ± 4.3</td>
<td>81.7 ± 5.6</td>
<td>85.1 ± 8.6</td>
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<tr>
<td><strong>BMI (kg/m^2)</strong></td>
<td>22.4 ± 2.5</td>
<td>23.5 ± 3.4</td>
<td>24.9 ± 3.4</td>
</tr>
<tr>
<td><strong>Pushups (max/1 min)</strong></td>
<td>44.9 ± 5.6</td>
<td>43.8 ± 11.0</td>
<td>41.1 ± 19.2</td>
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<tr>
<td><strong>Sit-ups (max/1 min)</strong></td>
<td>45.3 ± 15.2</td>
<td>52.3 ± 5.9</td>
<td>47.3 ± 9.3</td>
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<tr>
<td><strong>Average Free-Living Activity (min/wk)</strong></td>
<td>30.0 ± 41.1</td>
<td>28.4 ± 43.5</td>
<td>34.8 ± 48.6</td>
</tr>
</tbody>
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Table 2. Percent improvement (mean ± SD) on 1.5 mile run.

<table>
<thead>
<tr>
<th></th>
<th>Low Frequency (n=8)</th>
<th>High Frequency (n=9)</th>
<th>Continuous Training (n=10)</th>
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<tbody>
<tr>
<td>% Improvement by Time [95% CI]</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Baseline to 6 weeks</td>
<td>7.3 ± 4.2 * [0.9, 15.5]</td>
<td>9.7 ± 3.5 * [2.8, 16.6]</td>
<td>8.7 ± 4.8 * [-0.7, 18.1]</td>
</tr>
<tr>
<td>6 weeks to 10 weeks</td>
<td>-0.6 ± 3.6 [-7.7, 6.5]</td>
<td>-2.0 ± 2.3 [-6.5, 6.8]</td>
<td>-0.3 ± 3.3 [-6.8, 9.8]</td>
</tr>
<tr>
<td>Baseline to 10 weeks</td>
<td>6.7 ± 6.2 * [-5.5, 18.9]</td>
<td>7.9 ± 3.1 * [1.8, 14]</td>
<td>8.4 ± 6.0 * [-3.4, 20.2]</td>
</tr>
</tbody>
</table>

% Improvement by Session Completion [95% CI]

<table>
<thead>
<tr>
<th></th>
<th>Low Frequency (n=8)</th>
<th>High Frequency (n=9)</th>
<th>Continuous Training (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline to 15</td>
<td>6.7 ± 6.2 † [-5.5, 18.9]</td>
<td>9.7 ± 3.5 † [2.8, 16.6]</td>
<td>8.7 ± 4.8 * [-0.7, 18.1]</td>
</tr>
<tr>
<td>15 to 21</td>
<td>1.2 ± 2.6 [-3.9, 6.3]</td>
<td>-2.0 ± 2.3 [-6.5, 6.8]</td>
<td>-0.3 ± 3.3 [-6.8, 9.8]</td>
</tr>
<tr>
<td>Baseline to 21</td>
<td>7.9 ± 4.5 † [-0.9, 16.7]</td>
<td>7.9 ± 3.1 † [1.8, 14]</td>
<td>8.4 ± 6.0 * [-3.4, 20.2]</td>
</tr>
</tbody>
</table>

* Significant within-group difference for effects of time on run (p < 0.001)

† Significant within-group difference for effects of session completion on run (p < 0.001)