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High-Intensity Functional Training Induces Superior Training Adaptations Compared With Traditional Military Physical Training

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Abstract

Helén, J, Kyröläinen, H, Ojanen, T, Pihlainen, K, Santtila, M, Heikkinen, R, and Vaara, JP. High-intensity functional training induces superior training adaptations compared with traditional military physical training. *J Strength Cond Res* XX(X): 000–000, 2023—This study examined the effectiveness of concurrent strength and endurance training with an emphasis on high-intensity functional training (HIFT) during military service. Voluntary male conscripts (aged 18–28 years) were placed in either an experimental (EXP: $n =$ 50–66) or a control (CON: $n =$ 50–67) group. The training for the EXP group included HIFT using body mass, sandbags, and kettlebells. The CON group trained according to the current practice. Physical performance and body composition were assessed at baseline (PRE), at week 10 (MID), and after (POST) the 19-week training period. Significance was set at $p < 0.05$. The total distance covered in a 12-minute running test increased in both groups, but the change in EXP was superior to the change in CON (11.6%, ES: 0.79 vs. 5.7%, ES: 0.33; $p = 0.027$). Maximal strength and power characteristics increased in EXP (3.1–5.0%), whereas no improvements were observed in CON. Conscripts with the highest initial fitness showed no improvements in physical performance in either group. Body mass and waist circumference decreased in EXP, whereas CON showed an increase in muscle mass. These findings suggest that HIFT is an effective and time-efficient approach to improve soldiers' aerobic fitness during military service. For the optimal development of strength, the training equipment used may not have provided sufficient and progressive loading to yield considerable strength adaptations. More focus should be placed on sufficient intensity and volume in both strength and endurance training, especially for the most fit soldiers.

Key Words: exercise, fitness, strength, endurance, soldiers

Introduction

The modern warfighter is expected to have a wide range of physical capabilities because the tasks faced during combat require high levels of muscular strength and power, anaerobic performance, and aerobic fitness (9,20). However, the simultaneous development of these characteristics in a demanding military environment is a major challenge, especially in the most fit individuals (21). Improvements in strength and aerobic fitness are typically observed in soldiers with the lowest initial fitness (5,30). There are continuous efforts toward the development of optimal training strategies for soldiers.

Military physical training typically has a bias toward aerobic training because of its easy implementation and minimal equipment. It has been identified that aerobic fitness is an essential characteristic of a soldier's physical performance, but high volumes of endurance training may compromise strength adaptations during military training (21). This interference effect during concurrent strength and endurance training was first described by Hickson (14), but controversial findings have been reported in more recent studies (29,34). Although the universal concept of interference effect is equivocal, there is little doubt that the various stressors in the military environment—such as excessive low-intensity physical activity, negative energy balance, and sleep deprivation—have detrimental effects on the optimal development of physical performance (11,17,27).

The training load during military service can reach levels comparable to professional athlete training loads (17). Along with reducing total physical activity volume, adding variation to the training intensity is recommended because low-intensity to moderate-intensity activity alone does not seem to provide a sufficient stimulus to optimize aerobic fitness development during military training (8). Concurrent strength and endurance training including low-volume high-intensity training seems to be a viable training method for soldiers and may be effective to improve both aerobic and neuromuscular performance (6,10,21,36).

Therefore, the purpose of this study was to investigate the effects of concurrent strength and endurance training with an emphasis on high-intensity functional training (HIFT) on physical performance and body composition during military training. A focus was placed on easy implementation of the training and

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minimal usage of equipment and facilities. We hypothesized that the experimental training would induce greater improvements in both aerobic and neuromuscular performance when compared with the current practice.

Methods

Experimental Approach to the Problem

Conscripts who had entered for 5.5-month military service formed the sample population for this study. Two companies were selected to experimental (EXP) and control (CON) groups. Measurements of physical performance and body composition were conducted over a 5-day period 1 week before the start of the 19-week training intervention (PRE), repeated at training week 10 (MID), and again 1 week after training (POST) using identical protocols. All subjects were housed, fed, and trained at a military base.

Subjects

A total of 243 male conscripts volunteered to participate in this study. One hundred seventeen subjects were lost to follow-up after PRE or MID measurements due to unit transfer or cessation of the military service. Six subjects were lost (EXP 2; CON 4) due to lack of motivation to participate. The final study sample (n = 133) included subjects who took part in at least 2 measurement sessions (EXP: n = 66, age 19 ± 1 year [range 18–24 years], body mass 73.7 ± 12.7 kg, height 178 ± 7 cm; CON: n = 67, age 19 ± 1 year [range 18–25 years], body mass 73.3 ± 11.6 kg, height 179 ± 6 cm). No women participated because the units selected for the study had only men. The subjects provided a written informed consent form after they were informed about the design of the study and the benefits and possible risks associated with it. The study was conducted according to the Declaration of Helsinki and was approved by the Ethical Committee of the Central Finland Health Care District and the Finnish Defence Forces (AP10027). All subjects were screened and had no medical condition that would prevent participation in the study.

Procedures

The subjects were familiarized with the testing procedures, and a standardized warm-up was performed before each assessment. Maximal voluntary isometric contraction of the upper ($MVIC_{upper}$) and lower ($MVIC_{lower}$) body was measured in a seated position using an electromechanical leg and bench press dynamometer manufactured by the University of Jyväskylä, Finland (15). In the bench press measurement, the elbow angle was 90° and the bar was adjusted to shoulder height. In the leg press measurement, the knee angle was adjusted to 107°. The subjects were given 2 attempts in both tests to produce maximal force (N), separated by at least 30-second rest. The best results were selected for analysis. The reliability has been reported to be high in maximal isometric strength tests (ICC > 0.91) (25).

A seated medicine ball throw (SMBT) was used to measure upper-body power. The subjects were asked to sit on the floor, legs extended and in contact with each other and back firmly against the wall. A 7.5-cm-thick yoga block was placed between the wall and the lower back for support. The subjects were instructed to throw a 2-kg medicine ball off the chest with both hands while keeping their back in contact with the wall. The distance was measured from the wall to the middle of the landing point using a measurement tape placed securely on the floor. The subjects were allowed to practice 2–3 throws, followed by 3 measured maximal attempts with the best result selected for analysis. Reliability of 1.5- and 3.0-kg SMBT has been reported to be high (ICC = 0.994 and 0.989, respectively) (13).

Peak power of the lower extremities was assessed using a standing long jump (SLJ), which was performed using a countermovement and arm swing. The best result of 3 attempts was used for analysis. SLJ has shown high reliability (ICC = 0.95) (23). Muscle endurance of the abdominal and hip-flexor muscles, and upper body was assessed with 1-minute repeated sit-ups and push-ups, respectively. The total number of repetitions was recorded in both assessments. High reliability (ICC > 0.90) for repeated sit-ups and push-ups has been reported (4).

Aerobic fitness was assessed using the 12-minute running test (7), which was performed on an indoor grass turf track. The result was the total distance covered with the accuracy of 5 m.

Body composition characteristics (body mass, muscle mass, body fat mass, and body fat %) were measured in the morning after an overnight fast using the segmental multifrequency bioimpedance analysis (InBody 720/770; Biospace Co. Ltd., Seoul, South Korea) in accordance with the manufacturer's guidelines (2). A tape measure was used to measure waist circumference (WC). Height was measured at baseline with a wall-mounted stadiometer.

Exercise Training Programs. Training in the EXP group included concurrent strength and endurance training, with an emphasis on HIFT. The training was conducted in a way that allowed soldiers to individually adjust exercise intensity to provide a proper training stimulus, regardless of the initial fitness level. Along with body mass exercises, the additional training equipment included sandbags (Brute Force Training LLC, Arvada, CO) and kettlebells from 16 to 32 kg. The weight of the sandbags was adjustable between approximately 10 and 60 kg. Each EXP training session (60 minutes) commenced with a standardized warm-up, which included a short low-intensity aerobic exercise, dynamic stretching, and core stability exercises. Next, 1 or 2 strength exercises (Table 1) were performed with a varied number of sets (3–8), repetitions (5–15), and rest period durations (1–4 minutes) over the training sessions. The subjects were instructed to use loading that resulted in volitional failure in each set. Thereafter, a HIFT workout was performed with varied intensity, duration (5–30 minutes), and exercise selection in every session. Most of the workouts included circuit training, which involves different exercises performed with either a prescribed number of sets and repetitions as fast as possible or as many rounds as possible in a given time frame. For example, a circuit training with 10 burpees, 15 kettlebell swings, and 20 lunges was performed for as many rounds as possible in 20 minutes. To promote progression, the training load was gradually increased throughout the training period by increasing the volume load (sets × repetitions × load) in strength exercises and encouraging the subjects to increase intensity in HIFT workouts at their discretion. All training sessions were supervised by drill instructors who were familiarized with the training before the start of the experiment.

Subjects in the CON group trained in accordance with the current physical training guidelines of the Finnish Defense Forces. Training consisted of exercises that are traditionally used in a military context, such as running, ball games, and calisthenics (Table 2). The total volume of training during the intervention was 46 and 42 hours for EXP and CON, respectively. The proportion of HIFT in EXP was 30 hours. As some of the training objectives were necessary to perform, 16 hours of training in EXP was similar to CON (Table 2). In addition to the 5 hours of actual

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Table 1
Exercises used in the experimental training program.*

Squat (back/front)	BM/KB/SB
Lunge	BM/KB/SB
Deadlift	SB/KB
Bent over row (U/B)	SB/KB
Shoulder press (U/B)	SB/KB
Floor press	SB/KB
Kettlebell swing	KB
Standing long jump	BM
Push-up	BM
Burpee	BM
Running	BM
Ground to shoulder	SB
Lateral hop over sandbag	SB
Bear crawl drag	SB
Plank drag	SB
Farmers carry (U)	SB/KB
Burden carry	SB
Plank	BM
Side plank	BM
Mountain climber	BM
Sit-up	BM
Pike-up	BM
Russian twist	KB

*BM = body mass, KB = kettlebell, SB = sandbag, U = unilateral, B = bilateral.

running training in EXP, the HIFT workouts also included some running, which was performed in short sprints (200–400 m) as part of the circuit training. However, the total volume of running in HIFT workouts during the intervention was low (<5,000 m). The average frequency of training was twice a week for both groups. Of the total 33 and 35 training sessions in EXP and CON, mean (±*SD*) participation among subjects was 88 ± 9% and 91 ± 8%, respectively. Because the amount of military field exercises is typically higher in the latter part of the Finnish military service, the training volume for EXP and CON was 27 and 26 hours between PRE and MID measurements, and 19 and 16 hours between MID and POST measurements, respectively. Along with physical training, both groups conducted normal military training with similar requirements, such as combat training, material handling, shooting, marching, and theoretical education.

Statistical Analyses

Sample size estimation was based on improvements in the 12-minute run previously reported by Pihlainen et al. (30). As we assumed, for an increase of 5% in CON and 10% in EXP, the required sample size was $n = 63$ to detect a significant difference (alpha = 0.05, 80% power). A linear mixed-effects model was used to estimate changes within and between groups over the study period. Interactions between groups and time were tested with the F-test (Satterthwaite's method). Tukey's post hoc test was applied for within-group pairwise comparisons between time points. The effect sizes (ESs) were calculated as the mean difference between PRE-measurement and POST-measurement values divided by the standard deviation (*SD*) of the respective PRE-measurement value. ES values were considered as 0.2 = small, 0.5 = medium, and 0.8 = large effect. Pearson's correlation coefficients were calculated between the changes in measured variables. The final sample size, depending on the outcome variable in these analyses, was 50–66 for EXP and 50–67 for CON. In addition, subjects were categorized into tertiles based on the initial (PRE) result for each assessment to study the training responses in individuals with different baseline fitness levels. Statistical analysis was conducted with *R* (3.6.3). All data are presented as mean with *SD* where appropriate. The level of significance was set at $p < 0.05$.

Results

After the 19-week training period, improvements in running performance and maximal strength and power characteristics were observed in EXP (Table 3). A significant group × time interaction occurred for 12-minute run ($p = 0.027$), $MVIC_{upper}$ ($p = 0.017$), $MVIC_{lower}$ ($p = 0.003$), and SMBT ($p < 0.001$). The 12-minute run performance improved in EXP by 11.6% (238 ± 310 m, $p < 0.001$) and by 5.7% (100 ± 276 m, $p = 0.008$) in CON. The observed improvement occurred at the lowest baseline tertile (T1) in both groups ($p < 0.001$) and the middle tertile (T2) in EXP ($p < 0.001$), whereas subjects in the highest baseline tertile (T3) showed no change in either group (Figure 1).

$MVIC_{upper}$ improved by 3.8% (24 ± 70 N, $p = 0.001$) and $MVIC_{lower}$ by 5.0% (116 ± 408 N, $p = 0.02$) in EXP, whereas CON showed no change. SMBT improved by 3.1% (15 ± 38 cm, $p = 0.003$) in EXP, whereas a decrease of 2.2% (14 ± 42 cm, $p = 0.013$) was observed in CON (Table 3). However, improvements in muscular fitness in EXP occurred only in T1 and T2 for $MVIC_{upper}$ ($p < 0.001$ for all). No changes were observed in any baseline tertiles in CON. No significant group × time interaction was observed in sit-ups and push-ups. SLJ decreased by 2.3% (5 ± 12 cm, $p = 0.008$) in EXP between PRE and MID measurements, but returned to the baseline level in POST measurements.

Among body composition variables (Table 4), a significant group × time interaction occurred for body mass ($p = 0.001$), muscle mass ($p < 0.001$), and WC ($p = 0.002$). A decrease in body mass (1.6 ± 0.1 kg, $p = 0.001$) and WC (1 ± 0 cm, $p = 0.011$) was observed in EXP but not in CON, whereas CON showed an increase in muscle mass (0.7 ± 0.2 kg, $p < 0.001$). WC decreased in CON between PRE and MID measurements (2 ± 0 cm, $p < 0.001$) but returned to the baseline level in POST measurement. Although no significant group × time interaction was observed in body fat mass, it decreased in EXP (1.1 ± 0.2 kg, $p = 0.004$) between PRE and POST measurements. At baseline tertiles, body mass, body fat mass, and body fat % increased in T1 and decreased in T3 in both groups ($p < 0.01$ for all). An interaction in body mass between EXP and CON occurred in T1 ($p < 0.001$) as the increase in CON was higher and in T2 ($p < 0.001$) as body mass decreased in EXP, with no change observed in CON.

The decreases in body mass and body fat were not associated with the improved running performance in EXP, but a weak positive

Table 2
Components and volume (hours) of the experimental (EXP) and control (CON) training programs.

	EXP	CON
HIFT	30	0
Running	5	10
Ball games	0	13
Calisthenics	3	9
Swimming	2	2
Orienteering	3	3
Self-defense/hand-to-hand combat	2	2
Resistance training (gym)	1	3
Total (hours)	46	42

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Table 3

Mean (±*SD*) changes in physical fitness in the experimental (EXP) and control (CON) training groups.*

	PRE	MID	POST	Group × time interaction	ES ± *SD*
$MVIC_{upper}$ (N)					
EXP	816 ± 190	852 ± 179†	853 ± 172‡	$p = 0.017$	0.14 ± 0.41
CON	792 ± 144	791 ± 138	781 ± 142		−0.04 ± 0.32
$MVIC_{lower}$ (N)					
EXP	2,922 ± 638	3,025 ± 631	3,051 ± 660‡	$p = 0.003$	0.18 ± 0.64
CON	3,175 ± 623	3,055 ± 609	3,116 ± 661		−0.11 ± 0.65
SMBT (cm)					
EXP	538 ± 67	558 ± 69†	554 ± 65‡	$p < 0.001$	0.23 ± 0.57
CON	553 ± 65	539 ± 62†	539 ± 66‡		−0.21 ± 0.63
SLJ (cm)					
EXP	224 ± 26	219 ± 28†	220 ± 26	$p = 0.050$	−0.09 ± 0.46
CON	216 ± 27	218 ± 29	213 ± 25		−0.05 ± 0.48
Sit-ups (reps·min^{-1})					
EXP	36 ± 9	37 ± 8	36 ± 10	$p = 0.949$	−0.02 ± 0.92
CON	33 ± 9	34 ± 10	32 ± 10		−0.03 ± 0.60
Push-ups (reps·min^{-1})					
EXP	27 ± 13	29 ± 13	27 ± 12	$p = 0.413$	0.05 ± 0.64
CON	24 ± 10	26 ± 10	23 ± 11		−0.08 ± 0.66
12-min run (m)					
EXP	2,240 ± 287	2,426 ± 285†	2,471 ± 334‡	$p = 0.027$	0.79 ± 1.03
CON	2,210 ± 316	2,299 ± 312†	2,315 ± 286‡		0.33 ± 0.92

*ES = effect size, $MVIC_{upper}$ = maximal voluntary isometric contraction of the upper extremities, $MVIC_{lower}$ = maximal voluntary isometric contraction of the lower extremities, SD = standard deviation, SLJ = standing long jump, SMBT = seated medicine ball throw.
†Significant PRE–POST change ($p < 0.05$).
‡Significant PRE–MID change ($p < 0.05$).

correlation was observed between the change in 12-minute run and $MVIC_{lower}$ ($r = 0.28$, $p = 0.045$) and SLJ ($r = 0.38$, $p = 0.004$). By contrast, weak to moderate inverse correlations were observed between 12-minute run and body mass ($r = -0.33$, $p = 0.028$), body fat mass ($r = -0.45$, $p = 0.002$), and body fat % ($r = -0.44$, $p = 0.003$) in CON, but no associations were observed with lower-body strength variables.

Discussion

An experimental 19-week concurrent strength and endurance training program with a special emphasis on HIFT elicited greater improvements in aerobic fitness and muscle strength characteristics of the conscripts than traditional military physical training. Although the effect sizes were small in most of the observed changes, a more notable result was present in the 12-minute run.

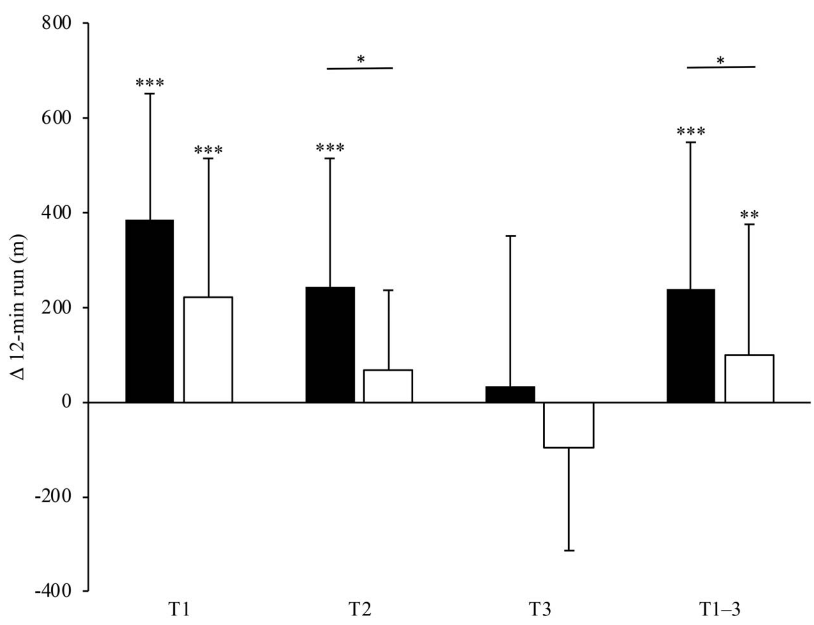

Figure 1. Mean (±*SD*) changes between PRE and POST measurements in the 12-minute run among baseline fitness tertiles (EXP: T1 < 2,165 m, T2 2,165–2,400 m, T3 > 2,400 m; CON: T1 < 2,155 m, T2 2,155–2,410 m, T3 > 2,410 m). *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

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Table 4
Mean (±*SD*) changes in body composition in the experimental (EXP) and control (CON) training groups.*

	PRE	MID	POST	Group × time interaction	ES ± *SD*
Body mass (kg)					
EXP	73.7 ± 12.7	73.1 ± 12.2	72.3 ± 10.7†	$p = 0.001$	−0.13 ± 0.37
CON	73.3 ± 11.6	73.4 ± 10.2	74.1 ± 9.4		0.06 ± 0.33
Muscle mass (kg)					
EXP	34.9 ± 4.9	34.9 ± 5.2	34.7 ± 4.6	$p < 0.001$	−0.06 ± 0.26
CON	34.5 ± 4.0	34.7 ± 3.8‡	35.2 ± 3.9†		0.15 ± 0.35
Body fat mass (kg)					
EXP	12.3 ± 7.2	11.8 ± 5.9	11.3 ± 5.1†	$p = 0.236$	−0.15 ± 0.50
CON	12.2 ± 7.2	12.0 ± 6.4	12.1 ± 5.6		−0.05 ± 0.42
Body fat %					
EXP	15.8 ± 7.2	15.4 ± 5.7	15.2 ± 5.3	$p = 0.344$	−0.10 ± 0.51
CON	15.8 ± 7.1	15.7 ± 6.3	15.8 ± 5.6		−0.02 ± 0.45
WC (cm)					
EXP	81 ± 8	80 ± 8	80 ± 6†	$p = 0.002$	−0.15 ± 0.48
CON	83 ± 9	81 ± 8‡	83 ± 8§		0.05 ± 0.47

*ES = effect size, SD = standard deviation, WC = waist circumference.
†Significant PRE–POST change ($p < 0.05$).
‡Significant PRE–MID change ($p < 0.05$).
§Significant MID–POST change ($p < 0.05$).

Both groups improved their physical performance, but the change in EXP was superior compared with CON. Muscle mass increased in CON, whereas body mass decreased in EXP compared with CON.

The observed improvement of 6% in the 12-minute run in CON is in line with Pihlainen et al. (30), who reported a similar 5% change in conscripts during 6–12 months of military service in the Finnish Defence Forces. The significantly larger improvement (12%) in EXP may be due to higher training adaptations, such as improved oxygen utilization and mitochondrial biogenesis induced by high-intensity training (10). This is also supported by the observation that the decreases in body mass and body fat were not associated with the improved running performance (24). In addition, the changes in strength characteristics could have affected the 12-minute run. It has been demonstrated that strength training can enhance endurance performance through several mechanisms, including improved running economy (1,28,32). The improvements in $MVIC_{lower}$ and SLJ were associated with the improvement in the 12-minute run, suggesting that training-induced neuromuscular adaptations may have contributed to running performance. It is also noteworthy that the volume of running training in EXP was ~50% lower than in CON. Thus, the primary explanation for the improvement is most likely due to the inclusion of high-intensity endurance training in EXP, which is considered beneficial for the development of aerobic fitness in soldiers (21,33).

Although EXP improved strength characteristics ($MVIC_{upper}$, $MVIC_{lower}$, and SMBT) compared with CON, the effect sizes for these changes were small. An increase in muscle mass was only observed in CON, suggesting that the strength gains in EXP were largely due to neural adaptations. Indeed, the early response to resistance training in untrained individuals is characterized by neural adaptations including motor learning and coordination, which can also be achieved using relatively light loads (19). Although the equipment used in experimental training in the present study was able to provide sufficient load to produce modest increases in strength, it is obvious that more progressive loading is needed with further training to develop maximal strength. A recent systematic review by Lopez et al. (22) showed that gains in maximal strength are significantly greater with high-load training (≥80% of 1RM) compared with moderate-load or low-load training. Furthermore, it is likely that the training volume in the present study was too low for the optimal development of strength. For training frequency, it seems that high (3–4 times/week) vs. low (1–2 times/week) training frequency results in similar strength gains when the volume is equated, especially in previously untrained individuals (12). For example, Häkkinen et al. (16) reported large (>20%) increases in 1RM strength of leg extensors during a 21-week training period in untrained subjects, with only 2 weekly training sessions. However, gains of this magnitude required sufficient loading and progression throughout the training. Burley et al. (6) reported a notable ~26% increase in 1RM squat after 12 weeks of low-volume high-intensity training in military recruits. In initially fit individuals, an improvement of this magnitude was achieved with 17 strength training sessions with sufficient training intensity and progression while reducing the total amount of endurance-type physical activity. In addition, recruits concurrently improved aerobic fitness with only 8 HIIT (running) and 2 load carriage training sessions. As military units are more likely to use low (1–2 times/week) strength training frequency because of practical reasons, the importance of maintaining a high training intensity needs to be emphasized.

The greatest improvements in fitness during military training are usually observed in soldiers with the lowest initial fitness levels, whereas soldiers with the highest fitness tend to decrease performance (5,30). Therefore, the experimental training in the present study was designed to provide a proper training stimulus for every soldier regardless of their fitness. For example, in workouts intended to complete a prescribed amount of work as fast as possible, or complete as many rounds as possible in a given time frame, each individual was able to adjust exercise intensity by modifying the pace, rest periods, or weights used. The subjects were instructed to increase intensity throughout the training intervention at their discretion. However, the compliance with these instructions remains unclear because no data were collected on the actual training intensity (e.g., weights used, heart rate, or rating of perceived exertion). Nevertheless, the absence of improvement in aerobic fitness in T3 could more likely be attributed to the relatively low total training volume. In some exercises

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targeted to improve maximal strength (e.g., back/front squat for <6 RM), the optimal training stimulus and progression for the strongest individuals were obviously limited by the maximum load that the equipment could provide. Although it was hypothesized that the experimental training would elicit greater adaptations in performance in the most fit individuals compared with CON (21), significant improvements were not observed in any of the measured physical performance variables in T3 in either group. These present findings further highlight the importance of the development of individualized training strategies that can provide sufficient training intensity, volume, and progression for soldiers with the highest initial fitness.

The volume of physical training was unevenly distributed during the intervention period because of the high amount of military field training exercises in the latter half of the study. This could partially explain why the observed improvements in performance in EXP occurred mostly between PRE and MID measurements and remained mostly unaltered between MID and POST measurements. It remains unclear whether further improvements would have occurred between MID and POST measurements if the training volume had been similar to the period between PRE and MID measurements. Nevertheless, with limited time committed to physical training, leaders should be advised to include, at least, some amount of exercise to maintain current levels of fitness. Spiering et al. (35) concluded that if exercise intensity is maintained or even increased, very little amount of exercise is needed to maintain fitness. Another strategy worth considering is to distribute the weekly training volume into several short sessions (e.g., 15 minutes) because it seems to result in similar adaptations as longer, less frequent sessions at the same total training volume (18).

The baseline body mass, body fat mass, and body fat % were inversely associated with their changes in both groups, which is in line with previous findings (30). However, in T1, the increase in body mass was lower in EXP compared with CON, whereas in T2, a decrease was observed only in EXP. Although there was no group × time interaction for body fat mass or body fat %, within-group comparisons revealed a decrease in body fat mass in EXP. These findings, along with the observed decrease in body mass and unaltered muscle mass in EXP, may reflect a negative energy balance during the study period, which could have attenuated performance and gains in muscle mass (3,26). Focus should be placed on adequate energy intake to promote soldier's health and the optimal development of physical performance and body composition (27).

The present study has some limitations. Subjects in EXP were encouraged to give effort to reach workloads that can be considered high-intensity training, but we were not able to collect data on actual training intensity during the training sessions (e.g., weights used, heart rate, or rating of perceived exertion). For this reason, the total training load and the desired progression in intensity could have differed to some extent between subjects, which may explain some of the large interindividual variation in the measured outcomes and the training response between the 3 different fitness level groups. Another factor that could have affected the training adaptations in EXP is the additional familiarization on how to instruct training sessions properly, which was given to drill instructors before and during the intervention. Roos et al. (31) demonstrated that the improvements in recruits' fitness are higher when the training is instructed by professional physical education teachers compared with training that is supervised by military physical training instructors. The level of instructors' expertise in the present study was obviously not comparable to physical education teachers, but because of the familiarization, the training sessions in EXP could have been conducted more effectively than in CON. Another limitation in this study is the relatively modest sample size. It is possible that we were not able to detect a true effect in some of the measured variables because the sample size estimation was based on the primary variable under interest (12-minute run). Thus, the study design can be deemed underpowered to detect differences in variables where high variance was observed (e.g., sit-ups and push-ups).

Practical Applications

Concurrent strength and endurance training, with an emphasis on HIFT, elicits superior adaptations in aerobic fitness when compared with traditional military physical training. Although the training equipment (sandbags and kettlebells) used in the present study proved to be a viable option for military physical training, their applicability to strength training is limited. For the optimal development of strength during military service, it is necessary to use equipment that can provide progressive loading. Furthermore, as low-volume HIFT seems to be a time-efficient method for the development of aerobic fitness in soldiers, it is likely beneficial to increase the proportion of time dedicated to strength training. Future studies aimed at developing optimal training programs for soldiers should focus on providing sufficient training intensity and volume in both strength and endurance training, especially for the most fit individuals.

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