

# Evaluation of the US Army Special Forces Tactical Human Optimization, Rapid Rehabilitation, and Reconditioning Program

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## ABSTRACT

**Background:** We sought to assess the rehabilitation process, training, performance, and injury rates among those participating and not participating in the Tactical Human Optimization, Rapid Rehabilitation, and Reconditioning (THOR3) program and determine injury risk factors. **Methods:** A survey inquiring about personal characteristics, injuries, physical performance, and THOR3 participation during the previous 12 months was administered to Army Special Operations Forces (SOF) Soldiers. Based on responses to physical training, Soldiers were categorized into three groups: a traditional physical training (TPT) group, a cross-training (CT) group, and a THOR3 group. To identify potential injury risk factors, risk ratios and 95% confidence intervals (95% CIs) were calculated. Backward-stepping multivariable logistic regression models were used to assess key factors associated with injury risk. **Results:** The survey was completed by 328 male Soldiers. Most of the Soldiers (62%) who scheduled an appointment with the physical therapist were seen within 1 day. Self-reported injury rates for the TPT, CT, and THOR3 groups were 70%, 52%, and 48%, respectively. When controlling for personal characteristics, unit training, and fitness, the TPT group had a marginally higher risk of being injured than the THOR3 group (odds ratio [OR], 2.72; 95% CI, 0.86–8.59;  $p = .09$ ). Soldiers who did not perform any unit resistance training ( $OR_{\text{none}/90-160 \text{ min}}$ , 3.62; 95% CI, 1.05–12.53;  $p = .04$ ) or the greatest amount of resistance training ( $OR_{>160 \text{ min}/90-160 \text{ min}}$ , 3.44; 95% CI, 1.64–7.20;  $p < .01$ ) were more likely to experience an injury than the moderate-resistance training group. **Conclusion:** THOR3 appears to offer human performance optimization/injury prevention advantages over other SOF human performance programs.

**KEYWORDS:** THOR3; physical fitness; physical training; musculoskeletal; athletic performance; injury

## Introduction

Special Operations Forces (SOF) personnel are a self-selected, elite, and highly trained group of military professionals who have a very high level of occupational physical demands during garrison preparedness training and operational deployments.

The need to optimize physical performance by robust physical training programs must also be balanced by prudent measures to mitigate injury risk. An optimized fitness program with low injury risk would have a positive effect on deployment capability and mission readiness.

However, SOF Soldiers require not only high levels of fitness but also high levels of functional/tactical skills to accomplish extraordinary physical demands and specialized tasks. During these specialized tasks, SOF Soldiers will routinely carry external loads, which influence performance and add to physiological challenges. These additional load carriage requirements during deployments have increased throughout the years and can affect gait, mobility, and metabolic rate, as well as elevating muscle fatigue and increasing the risk of injury.<sup>1,2</sup> Therefore, to ensure all SOF Soldiers are healthy and operating at maximum potential, the US Special Operations Command implemented a human performance program in 2009 termed the Tactical Human Optimization, Rapid Rehabilitation and Reconditioning (THOR3) program.

The THOR3 program is a human performance and rehabilitation program with its own facilities (i.e., human performance training centers with musculoskeletal [MSK] rehabilitation clinics) and personnel consisting of physical therapists (rehabilitation), athletic trainers (human performance and rehabilitation), a performance dietitian (human performance and rehabilitation), a performance psychologist (human performance and rehabilitation), and strength and conditioning coaches (human performance). The THOR3 program seeks to optimize tactical performance and enhance operational readiness. It focuses on task-specific training designed to optimize Operator performance for a particular mission set. The THOR3 program also seeks to optimize physical and mental conditioning of Army Special Operation Forces (ARSOF) personnel and to elevate the physical function, conditioning, and recovery of injured SOF back to peak physical and mental performance. The THOR3 program focuses on strength, endurance, and mobility for physical conditioning. To date, to our knowledge, no published data are available to demonstrate the efficacy or the return on this substantial investment.<sup>3</sup>

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Previous to THOR3 (2009) and the Army Physical Readiness Training program (an Army-wide physical training program),<sup>4</sup> physical fitness programs in the Army were heavily influenced by the American College of Sport Medicine exercise prescription guidelines, which are tailored for civilian populations and not representative of Soldiers' tasks. Traditional unit physical training-type exercise programs consisted of daily runs and calisthenic exercises.<sup>5</sup> No studies, to our knowledge, have evaluated the THOR3 program. However, a previous report of THOR3 resource use called for a more extensive study of the THOR3 program.<sup>3</sup> The primary objectives of the current evaluation are to provide survey metrics pertaining to the THOR3 rehabilitation process; to compare training, human performance, and injury rates among THOR3 and non-THOR3 participants; and to determine injury risk factors for those participating in THOR3.

## Methods

### Participants

Participants were ARSOF Soldiers. Hereafter, the term ARSOF Soldiers or Soldiers will refer to both SOF graduates (an 18 series military occupational specialty) and SOF support staff. Participation in THOR3 was optional for both SOF graduates and SOF support staff. This evaluation was reviewed and approved by the US Army Public Health Center Review Board.

### Survey

A survey was used to collect personal characteristics such as age, height, weight, military occupational series, and most recent Army Physical Fitness Test (APFT) results. Close correlations have been found between actual APFT scores and self-reported APFT scores, as well as actual and self-reported height and weight.<sup>6</sup> Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared ( $\text{kg}/\text{m}^2$ ). Physical training data were collected for unit and personal physical training.

Based on survey responses to unit and personal physical training, Soldiers could be categorized into three groups. The first group, the traditional physical training (TPT) group, generally performed more running and less cross-training (when compared with the other groups) during unit physical training. They did not participate in the THOR3 program for unit or personal fitness training. A second group performed a combination of cross-training (i.e., training for several different components of fitness) and/or extreme conditioning programs (i.e., workouts with a variety of high-intensity exercise repetitions and short rest periods) and/or physical readiness training (i.e., exercise programs designed to meet the physical demands of any combat or duty position as defined in Field Manual 7-22)<sup>4</sup>; however, they did not participate in the THOR3 program for both unit and personal fitness training. This group was referred to as the cross-training (CT) group. The third group performed a combination of exercise programs such as CT and/or extreme conditioning and/or physical training as well as participating in a supervised THOR3 program as part of their unit physical training. For example, they may have participated in a supervised THOR3 training program three times a week and performed CT on the other days. This group was referred to as the THOR3 group. Soldiers in the TPT and CT groups who made appointments with the THOR3 physical therapist and dietitian were not excluded from these groups. Soldiers were also asked about injuries occurring within the

last 12 months, where the injury occurred (body area), cause, and associated activities.

### Data Analysis

SPSS<sup>®</sup>, version 19.0 (IBM, <https://www.ibm.com>), was used for statistical analysis. Means, standard deviations, and frequencies were calculated for personal characteristics, physical fitness, and physical performance. For some questions, Soldiers could select all answers that applied. Therefore, total response-rate percentages may exceed 100%. Injury incidence was calculated as the number of Soldiers with one or more injuries divided by the total number of Soldiers surveyed. A  $\chi^2$  test was used to compare self-reported injury rates and the number of physical therapy visits among the three groups. An analysis of variance with a post hoc Tukey test was used to determine any differences among the three groups regarding personal characteristics, physical fitness, and physical performance. To identify potential injury risk factors among Soldiers, injury risk ratios and 95% confidence intervals (95% CIs) were calculated using self-reported injury data. Forced and backward-stepping multivariable logistic regression models were used to assess key factors for association with injury risk in this population. Variables entered into the models were chosen from the unadjusted model and had  $p$  value  $\leq .05$  or were needed to control for other known risk factors. Odds ratios (ORs) and 95% CIs were calculated for each potential risk factor. Means are reported  $\pm$  standard deviation.

## Results

There were 328 ARSOF Soldiers who completed surveys and could be categorized into specific unit physical training groups (i.e., TPT, CT, and THOR3). The TPT group consisted of 41% ( $n = 11$ ) SOF graduates and 59% ( $n = 16$ ) SOF support Soldiers. The CT group consisted of 71% ( $n = 61$ ) SOF graduates and 29% ( $n = 25$ ) SOF support Soldiers. The THOR3 group consisted of 76% ( $n = 177$ ) SOF graduates and 18% ( $n = 38$ ) SOF support Soldiers. Overall, 66% ( $n = 215$ ) of the SOF Soldiers participated in THOR3, 26% ( $n = 86$ ) in CT, and 8% ( $n = 27$ ) in a TPT program. Mean age was  $33.2 \pm 6.3$  years and mean BMI was  $27.1 \pm 2.5$   $\text{kg}/\text{m}^2$ .

Approximately 69% of the Soldiers ( $n = 226$ ) had an appointment or consultation with a THOR3 physical therapist (TPT, 63%; CT, 59%; THOR3, 74%). A greater percentage of Soldiers in the THOR3 group had an appointment or consultation with the physical therapist compared with the CT group ( $p = .02$ ). On average, it took  $2.4 \pm 3.6$  days to see a THOR3 physical therapist from the time the THOR3 staff was notified; 62% of the Soldiers were seen by a THOR3 physical therapist within 1 day. Soldiers visited the physical therapist  $14 \pm 20$  times; 60% of the injured Soldiers reported complete recovery from their injury.

Approximately 43% of the Soldiers consulted with the dietitian. The top two reasons for visiting the dietitian were improved performance (66%) and healthier eating (54%). More than half (54%) of the Soldiers reported taking dietary supplements. The top three supplements taken were vitamins (46%), performance/muscle enhancement supplements (30%), and healthy-joint supplements (26%).

Approximately 83% to 85% of Soldiers who participated in THOR3 reported improvements in aerobic capacity, muscular

strength, and core strength. When given the opportunity to provide any additional written comments about the THOR3 program, 53% provided comments; 85% described THOR3 as very positive and beneficial.

Table 1 lists data as means and standard deviations for men in all three unit physical training groups by APFT fitness performance, unit physical training, personal physical training, and total unit and personal physical training performed per week. Soldiers in the THOR3 group outperformed those in the TPT group on all three physical fitness assessments. They also ran fewer miles per week (both unit and personal physical training) and performed more unit agility training, unit CT, unit sprinting, unit resistance training, and exercise (both unit and personal) per week compared with the TPT group. Soldiers in the THOR3 group performed more unit agility training and less personal running compared with the CT group. The TPT, CT, and THOR3 groups had similar mean and standard deviation data for age, BMI, unit running distance, unit and personal aerobic training excluding running, personal sprinting, personal CT, personal agility training, personal resistance training per week, and road distance marched per month (not shown). It may also be noted that the CT group outperformed the TPT group on all physical fitness assessments and

performed more unit agility training, unit CT, unit sprinting, unit resistance training, and exercise (both unit and personal) per week.

Overall self-reported injury incidence was 51%. Self-reported injuries for the TPT, CT, and THOR3 groups were 70%, 52%, and 48% ( $p = .03$ ), respectively. The TPT group was 46% more likely to experience an injury than the THOR3 group (TPT/THOR3 risk ratio [RR], 1.46; 95% CI, 1.10–1.93;  $p = .03$ ). However, in a multivariate model controlling for personal characteristics, unit training, and fitness, the TPT group had a marginally higher risk of being injured when compared with the THOR3 group (OR, 2.72; 95% CI, 0.86–8.59,  $p = .09$ ). There were no differences in self-reported injury rates between the CT and THOR3 groups.

Table 2 lists self-reported injuries by type, cause, and activity. The most common types of injuries were overuse sprains and strains (32%), followed by muscle and ligament tears (24%). The THOR3 group had a higher percentage of sprain/strain overuse injuries (35%) than the TPT (21%) and CT groups (29%). The most common causes for injury were overexertion and strenuous or repetitive movements (54%), followed by slips, trips, and falls (29%). The THOR3 group had a

**TABLE 1** Differences in Self-Reported Survey Performance and Physical Training Time for the Three Human Performance Programs

Training	TPT	CT	THOR3	ANOVA <i>p</i> Value	ANOVA With Tukey Test (Specific Interactions) <i>p</i> Values
Supervised exercise program	No	No	Yes		
<b>Push-ups</b>					
Repetitions	70 ± 12 (↓ 10%) (↓ 9%)	77 ± 9 (NS) (Ref)	78 ± 11 (Ref)	<.01	THOR3 – TPT: <.01 CT – TPT: <.01
<b>Sit-ups</b>					
Repetitions	73 ± 11 (↓ 10%) (↓ 10%)	81 ± 9 (NS) (Ref)	81 ± 9 (Ref)	<.01	THOR3 – TPT: <.01 CT – TPT: <.01
<b>2-mile run</b>					
Minutes and fraction of a minute	14.7 ± 1.3 (↑ 7%) (↑ 6%)	13.8 ± 1.1 (NS) (Ref)	13.7 ± 1.1 (Ref)	<.01	THOR3 – TPT: <.01 CT – TPT: <.01
<b>Unit physical training, min/wk</b>					
Run time	69 ± 37 (↑ 25%)	62 ± 37 (NS)	55 ± 32 (Ref)	.05	THOR3 – TPT: .08
Agility training	4 ± 10 (↓ 86%) (↓ 80%)	20 ± 26 (↓ 31%) (Ref)	29 ± 27 (Ref)	<.01	THOR3 – TPT: <.01 THOR3 – CT: .01 CT – TPT: .02
CT	15 ± 38 (↓ 83%) (↓ 79%)	73 ± 73 (NS) (Ref)	88 ± 72 (Ref)	<.01	THOR3 – TPT: <.01 CT – TPT: <.01
Sprinting	10 ± 16 (↓ 72%) (↓ 66%)	29 ± 31 (NS) (Ref)	36 ± 30 (Ref)	<.01	THOR3 – TPT: <.01 CT – TPT: .01
Resistance training	43 ± 64 (↓ 68%) (↓ 71%)	144 ± 153 (NS) (Ref)	135 ± 95 (Ref)	<.01	THOR3 – TPT: <.01 CT – TPT: <.01
<b>Personal physical training, min/wk</b>					
Run time	69 ± 48 (NS)	69 ± 52 (↑ 33%)	52 ± 39 (Ref)	<.01	THOR3 – CT: <.01
<b>Exercise time</b>					
Total (unit and personal) physical training	448 ± 278 (↓ 60%) (↓ 81%)	810 ± 372 (NS) (Ref)	718 ± 337 (Ref)	<.01	THOR3 – TPT: <.01 CT – TPT: <.01

Data reported as mean ± standard deviation. Percentages in parentheses represent the percentage difference from the indicated reference group. ANOVA, analysis of variance; CT, cross-training; NS, not significant; Ref, reference; THOR3, Tactical Human Optimization, Rapid Rehabilitation, and Reconditioning; TPT, traditional physical training.

lower percentage of slips, trips, and falls (26%) than the TPT (37%) and CT groups (31%). The most common types of activities associated with injury were physical training (unit or personal; 43%), lifting or moving heavy objects (11%), and combat (11%). The THOR3 group had a lower percentage of physical training injuries (42%) when compared with the CT group (51%) but higher than the TPT group (26%). The THOR3 group also had a lower percentage of injuries due to lifting or moving heavy objects (10%) when compared with the TPT group (26%) and the lowest percentage of airborne injuries (7%) when compared with the TPT (11%) and CT groups (18%).

Table 3 displays injury risk associated with personal characteristics, unit physical fitness training, and fitness performance for Soldiers participating in a THOR3 supervised program. Soldiers who were between 37 and 41 years old, performed the most resistance training, did not participate in unit sprint

training, performed the most agility training, and did not perform unit road marching were at a higher risk of injury.

A backwards-stepping multivariable analysis was performed (using variables from Table 3 with  $p \leq .05$  and 2-mile run time); unit resistance training was the only variable that remained in the final model. The amount of resistance training performed was  $53 \pm 20$  minutes for the <90-minutes group,  $119 \pm 22$  minutes for the 90–160-minutes group, and  $240 \pm 75$  minutes for the >160-minutes group. Soldiers who did not perform any unit resistance training were 3.62 times more likely to experience an injury compared with the moderate unit resistance training group ( $OR_{\text{none/90-160 min}}, 3.62; 95\% \text{ CI}, 1.05\text{--}12.53; p = .04$ ). Soldiers who performed more than 160 minutes of resistance training were 3.44 times more likely to experience an injury compared with the moderate unit resistance training of 90–160 minutes ( $OR_{>160 \text{ min}/90-160 \text{ min}}, 3.44; 95\% \text{ CI}, 1.64\text{--}7.20; p < .01$ ).

**TABLE 2** Self-Reported Injury Types, Causes, and Activities by Fitness Performance Group

Injury Type	No. of Injuries (% of Total)	TPT	CT	THOR3
<b>Type</b>				
Sprain/strain overuse	53 (32)	4 (21)	13 (29)	36 (35)
Tear (muscle/ligaments)	41 (24)	5 (26)	10 (22)	26 (25)
Spinal injury (e.g., bulging or slipped disk)	21 (13)	3 (16)	3 (7)	15 (14)
Sprain/strain traumatic	15 (9)	2 (11)	6 (13)	7 (7)
Fracture/break	12 (7)	3 (16)	3 (7)	6 (6)
Blunt force trauma	8 (5)	1 (5)	5 (11)	2 (2)
Dislocation	5 (3)	1 (5)	3 (7)	1 (1)
Nerve injury	3 (2)	0 (0)	1 (1)	2 (2)
Cut/laceration	3 (2)	0 (0)	0 (0)	3 (3)
Fasciitis	2 (1)	0 (0)	0 (0)	2 (2)
Bruise/contusion	2 (1)	0 (0)	0 (0)	2 (2)
Heat injury	0 (0)	0 (0)	0 (0)	0 (0)
Other	3 (2)	0 (0)	1 (2)	2 (2)
<b>Associated cause</b>				
Overexertion, strenuous or repetitive movements	91 (54)	10 (53)	24 (53)	57 (55)
Fall, jump, slip, or trip	48 (29)	7 (37)	14 (31)	27 (26)
Struck against or by an object or person	8 (5)	1 (5)	0 (0)	7 (7)
Bullet/grenade/projectile	6 (4)	0 (0)	1 (2)	5 (5)
Direct or indirect contact by enemy	2 (1)	0 (0)	1 (2)	1 (1)
Cut or puncture by a sharp tool, object, or instrument	1 (1)	0 (0)	0 (0)	1 (1)
Burn (by fire, not substance, object, or steam)	0 (0)	0 (0)	0 (0)	0 (0)
Other	12 (7)	1 (5)	5 (11)	6 (6)
<b>Associated activity</b>				
Physical training	72 (43)	5 (26)	23 (51)	44 (42)
Lifting or moving heavy objects (not weight training)	18 (11)	5 (26)	3 (7)	10 (10)
Combat	18 (11)	2 (11)	3 (7)	13 (13)
Airborne operations	17 (10)	2 (11)	8 (18)	7 (7)
Marching with load	9 (5)	1 (5)	3 (7)	5 (5)
Sports/recreation	7 (4)	1 (5)	1 (2)	5 (5)
Gunshot, missile, blast	4 (2)	0 (0)	0 (0)	4 (4)
Riding or driving in a motorized vehicle	3 (2)	0 (0)	0 (0)	3 (3)
Walking or hiking	3 (2)	0 (0)	1 (2)	2 (2)
Rough housing or fighting	1 (1)	0 (0)	1 (2)	0 (0)
Repairing or maintaining equipment	1 (0)	1 (5)	0 (0)	0 (0)
Stepping/climbing	0 (0)	0 (0)	0 (0)	0 (0)
Other	15 (9)	2 (10)	2 (4)	11 (11)

CT, cross-training; THOR3, Tactical Human Optimization, Rapid Rehabilitation, and Reconditioning; TPT, traditional physical training.

**TABLE 3** *Unadjusted Results for Personal Characteristics, Unit Physical Training, and Fitness Performance for Soldiers Participating in a THOR3 Supervised Training Program*

Variable	No.	Injured, %	Risk Ratio, 95% CI	p Value
<b>Age, years</b>				
<27	21	48	1.25 (0.73–2.13)	.43
27–31	76	38	1.00	
32–36	60	50	1.31 (0.89–1.92)	.17
37–41	29	69	1.81 (1.24–2.63)	>.01
<41	29	52	1.33 (0.87–2.05)	.18
<b>BMI, kg/m<sup>2</sup></b>				
≤25.8	73	41	1.00	
25.9–28.1	77	52	1.26 (0.89–1.79)	.18
>28.1	65	52	1.27 (0.89–1.82)	.19
<b>Unit running distance per week, miles</b>				
None	9	56	1.17 (0.60–2.28)	.66
2–4	40	48	1.00	
5–7	65	43	0.91 (0.59–1.39)	.66
8–10	53	48	0.99 (0.64–1.53)	.97
>10	32	53	1.12 (0.71–1.77)	.64
<b>Unit resistance training, min/wk</b>				
None	15	60	1.68 (1.00–2.82)	.08
<90	57	47	1.33 (0.87–2.01)	.18
90–160	70	36	1.00	
>160	73	59	1.65 (1.14–2.38)	<.01
<b>Unit sprinting per week, min/wk</b>				
None	20	65	1.63 (1.04–2.54)	.05
<21	59	53	1.31 (0.89–1.95)	.17
21–40	60	40	1.00	
>40	75	48	1.2 (0.81–1.77)	.35
<b>Unit agility training, min/wk</b>				
None	40	50	1.46 (0.85–2.51)	.16
<20	38	34	1.00	
20–39	65	48	1.39 (0.84–2.32)	.18
>39	69	54	1.57 (0.28–38.54)	.05
<b>Unit aerobic training not excluding running, min/wk</b>				
None	43	42	0.80 (0.51–1.26)	.33
<31	59	51	0.97 (0.66–1.42)	.88
31–60	61	48	0.91 (0.61–1.34)	.63
>60	42	52	1.00	
<b>Unit CT per week, min</b>				
None	11	36	0.72 (0.32–1.62)	.38
<41	58	43	0.85 (0.58–1.24)	.39
41–109	69	51	1.00	
>109	71	49	0.97 (0.70–1.35)	.87
<b>Unit road marching distance per month, miles</b>				
None	25	68	1.75 (1.07–2.85)	.03
<7	42	48	1.22 (0.73–2.06)	.44
7–12	65	48	1.23 (0.76–1.97)	.39
13–20	38	45	1.15 (0.67–1.98)	.61
>20	36	39	1.00	
<b>Total unit fitness training, min/wk</b>				
15–260	42	48	1.09 (0.73–1.63)	.68
261–434	80	44	1.00	
> 434	93	53	1.20 (0.88–1.65)	.24
<b>Sit-ups, no.</b>				
≤77	55	49	0.96 (0.68–1.35)	
78–83	79	43	0.84 (0.60–1.17)	.80
≥84	76	51	1.00	.30
<b>Push-ups, no.</b>				
≤74	54	52	1.00	
75–82	91	44	0.85 (0.60–1.20)	.36
≥83	65	49	0.95 (0.66–1.36)	.78
<b>2-mile run, min</b>				
≤13.25	84	41	1.00	
13.26–14.25	68	54	1.34 (0.96–1.89)	.09
≥14.26	53	49	1.21 (0.83–1.77)	.32

## Discussion

This survey analysis assessed the THOR3 rehabilitation program, fitness training, fitness performance, injury rates, and injury risk factors for Soldiers. Most of the Soldiers reported a consultation or visit with the physical therapist, were seen within 1 day, and reported full recovery from their injuries. Soldiers who included THOR3 as part of their training program outperformed the TPT group on all self-reports of physical fitness tests and were marginally less likely to experience an injury than the TPT group when controlling for personal characteristics, unit training, and fitness.

### THOR3 MSK Rehabilitation Clinic

Unlike most physical therapy clinics located within the hospital or troop medical clinics, THOR3 MSK rehabilitation clinics are colocated within the THOR3 human performance training centers, which is, itself, located within the ARSOF Group footprint. ARSOF Soldiers do not need a referral from their primary physician; they can go directly to the MSK rehabilitation clinic and set up an appointment. This process is more efficient and enables immediate or very rapid identification of an injury and rehabilitation to begin within the same day or a few days later. This is dissimilar to the experience of conventional Soldiers, who first have to be seen by their primary care physician and then be referred to the physical therapist. This process, on average, takes approximately 10 to 14 days before the physical therapist can be seen (LTC Patrick Depenbrock, personal communication).

During or upon completion of physical therapy, ARSOF Soldiers have the option to continue rehabilitation with the certified strength and conditioning coaching staff. Supervised rehabilitation has been shown to reduce the number of reinjuries and to improve functional outcomes compared with home based exercises.<sup>7</sup> In a systematic review of supervised rehabilitation programs versus home exercise programs for acute ankle sprains, supervised programs were shown to result in less pain and self-reported instability at follow-up and greater gains in strength.<sup>7</sup> On average, an injured ARSOF Soldier visited the physical therapy clinic 14 times; more than half of the ARSOF Soldiers reported complete recovery. This may be similar to in-house athletic training programs or athletic-like training programs for which a more rapid return to work<sup>8</sup> and a reduction in lost work days have been shown.<sup>8,9</sup> It was also shown that in-house athletic training or athletic-like training programs can be cost effective than outsourcing medical care.<sup>10</sup> Therefore, THOR3 provided early identification, a supervised rapid rehabilitation program, and complete recovery for most of the ARSOF Soldiers.

### Unit Physical Training Differences and Performance

The amount of time spent performing a variety of physical training activities was generally similar between the THOR3 and CT groups (except for unit agility training and personal run time). However, both the THOR3 and CT groups spent more time performing a wider variety of physical training compared with the TPT group (i.e., cross-training, sprint training, resistance training, agility training). Even though there were a few differences in the CT and THOR3 training programs, they both outperformed the TPT group on all three APFT events. The greater amount of time spent performing a wider variety of physical training for the CT and THOR3 groups may

have had an influence on fitness performance. Some of this additional physical training (i.e., cross-training and sprinting) incorporated high-intensity intermittent training (HIIT). Previous studies investigating HIIT-type programs have reported that performance improves with the addition of HIIT.<sup>11-13</sup> In a US Air Force study, running mileage was decreased by 50% and long distance runs were replaced with interval running and agility training. Investigators found that by replacing traditional training with the new functional training program, improvements were made in body composition, aerobic capacity, ventilatory threshold, and upper body power.<sup>13</sup> In a study of triathletes, one group continued with their regular training (control group), while the other group decreased their running mileage by 70% and performed HIIT in place of running (experimental group). After 5 weeks of training, the experimental group improved their athletic performance on a sprint-distance triathlon, whereas no changes occurred in control group performance.<sup>11</sup> When specifically looking at CT programs, adding additional exercise components to a program has shown no change or an improvement in performance.<sup>14-18</sup> It would seem that implementing a wider variety of exercises, including HIIT type programs, not only improves performance but also can be more combat-skills focused and meet mission-specific requirements compared with TPT programs that primarily consist of running, push-ups, and sit-ups.

Another consideration influencing performance could be the amount of time spent performing physical training. The total amount of time exercised per week among the three programs was significantly different. The CT and THOR3 groups performed an additional 6 hours and 4.5 hours, respectively, when compared with the TPT group. Therefore, the additional time spent exercising and performing various types of training may have affected physical performance.

There is, however, a limitation when comparing these three groups. The majority of SOF Soldiers in the CT and THOR3 groups were SOF graduates, whereas the majority of SOF Soldiers in the TPT group were support Soldiers and not SOF graduates. Therefore, the different roles and requirements of these jobs may have had an influence on fitness performance and the amount of time spent exercising per week.

### *Injury Rates*

When controlling for personal characteristics, unit training, and fitness, the TPT group had a marginally higher risk of being injured when compared with the THOR3 group. However, when comparing the CT and THOR3 groups, whose physical training programs were fairly similar, there were no differences in injury rates.

The marginal differences in the self-reported injuries when comparing the TPT and THOR3 programs may be attributed to differences in the amount of time spent performing different types of physical training activities and to the THOR3 human performance team. Physical training differences included more time spent per week performing sprinting, cross-training, agility training, and resistance training for the THOR3 group when compared with the TPT group. The TPT group also spent more time running per week (marginal finding) compared with the THOR3 group. In previous military studies that investigated the implementation of new exercise programs (i.e., incorporating additional CT components), injury rates remained similar or decreased with the implementation of a CT-like program.<sup>13,19,20</sup>

In particular, a unit training activity performed by the THOR3 group and minimized by the TPT group was agility training. In a systematic review investigating prevention strategies for physical training-related injuries, strong evidence was shown that agility-like training consistently demonstrated reduction in injury rates across multiple studies.<sup>21</sup> Some of the reasons for reduced injury rates associated with agility-like training might include (1) neurophysiological learning enabling participants to move their bodies in a smoother, more coordinated fashion; (2) MSK stress of training is more evenly spread across the body; (3) strength and stabilization movements performed during agility training may represent complex combat activities; and (4) the incorporation of these activities may reduce excessive exposure to running activities.<sup>21</sup>

### *Risk Factors for Resistance Training*

Studies have shown that resistance training improves physical and occupational task performance.<sup>22-24</sup> It has also been shown that endurance training concurrent with resistance training improves load-bearing performance,<sup>17,22,25,26</sup> heavy lifting tasks,<sup>17</sup> and increases short- and long-term endurance capacity in sedentary and trained individuals.<sup>27</sup> Although a few studies have shown endurance training to have a negative impact on muscle strength,<sup>28,29</sup> more have shown no impact on muscular strength.<sup>24,30-32</sup> In the present investigation, too much unit resistance training compared with a moderate amount of resistance training was a risk factor for injury, whereas a moderate amount of unit resistance training was protective against injury when compared with no resistance training. Previous military investigations have indicated that strength training reduces injury risk and improves human performance.<sup>13,20</sup> In an investigation of infantry Soldiers, those who participated in unit resistance training at least once a week were at a lower injury risk than Soldiers who did not perform any unit resistance training.<sup>20</sup> In an Air Force study, most traditional long-distance running was replaced with interval running, agility training, and functional strength training. This resulted in a 67% decrease in overall injury rates, with trainees scoring higher on nearly all the measured fitness parameters.<sup>13</sup> When looking specifically at the amount of time spent resistance training and its association with injury risk, we found no available evidence in the literature. The results from this investigation suggest that a moderate amount of resistance training should be performed during unit physical training.

### *Conclusion*

Most Soldiers in this study reported improvements in physical fitness and operational readiness as a result of THOR3. Having an onsite MSK rehabilitation clinic allowed most Soldiers with injuries to be seen within 1 day and more than half of the Soldiers reported complete recovery from their injuries. This evaluation found that the THOR3 group had marginally lower self-reported injury rates when compared with the TPT group. Independent risk factors identified from this evaluation suggest that those participating in THOR3 perform a moderate amount of unit resistance training. The overall results of this evaluation suggest that THOR3 offers human performance optimization/injury prevention advantages over other ARSOF human performance programs.<sup>33</sup>

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#### Author Contributions

TG was responsible for project plan development, data management, data analysis, interpretation, and reporting. MA was responsible for data management, data analysis, interpretation, and reporting. PD, RE, BN, and BJ were responsible for project plan development, interpretation, and reporting.

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