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Effects of an 8-Week Undulating Training Program on Firefighter Body Composition, Muscular Fitness, and Occupational Performance

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EFFECTS OF AN 8-WEEK UNDULATING TRAINING PROGRAM ON FIREFIGHTER BODY COMPOSITION, MUSCULAR FITNESS, AND OCCUPATIONAL PERFORMANCE

by

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Abstract

BACKGROUND: Firefighting is a high-risk occupation that requires a certain level of health and fitness to ensure optimal occupational performance. Improving body composition by reducing fat mass and increasing muscular strength and power are two great methods for improving performance. Therefore, the purpose of this study is to examine how an 8-week undulating training program affects firefighter body composition, muscular strength/power, and occupational performance. **METHODS**: A total of 33 active male firefighters were recruited for this study. Prior to the start of the 8-week undulating program, all participants were pre-tested on several fitness variables including body composition, strength, power, and occupational performance. The following week upon completion of the program, all participants were post-tested on the same fitness variables. The effects of the undulating program on the fitness variables were analyzed using a paired samples t-test. The level of significance was set at $p < 0.05$. **RESULTS**: All body composition variables saw a significant increase from pre-to-post which included WT ($p = 0.002$), MM ($p = 0.022$) and BFP ($p = 0.021$). There was also a significant increase in both strength variables which included DOM HGS ($p = 0.023$) and NON-DOM HGS ($p = 0.025$), however we did not see a significant increase in CMJ ($p = 0.464$). Occupational performance saw the most significant improvement ($p = 0.001$). CONCLUSION: These findings show the importance of having a structured program to further improve

firefighters' health, fitness, and occupational performance. All departments should look to implement their own health and wellness program for the betterment of their firefighters.

INDEX WORDS: Tactical, Firefighter, Undulating, Programming, Occupational, Training

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INTRODUCTION

Purpose of the Study

The purpose of this study is to examine how an 8-week undulating training program affects firefighter body composition, muscular strength/power, and occupational performance.

How This Study is Original

While there are some studies that examine the effects of a training program(s) on the general population, there is only one study to date that examines the effects of an undulating program on firefighters. While that study looks at how strength and occupational performance are affected by an undulating program, to the best of our knowledge, this is the first study that looks at the effects on firefighter body composition.

Chapter 2

BACKGROUND

Firefighting is a physically demanding and extremely dangerous occupation. Firefighters perform strenuous work in dangerous and unpredictable environments requiring optimal physical conditioning (Ras et al., 2023). Some examples include high-intensity work in thermally intense environments while wearing heavy (approximately 22 kg) and cumbersome personal protective equipment (PPE) and carrying and using tools needed to perform specific job tasks (Storer et al., 2014). Due to the extreme demands of the job, increasing firefighter health and fitness should be a priority for all departments (NFPA, 2022). The National Fire Protection Association (NFPA) annual report continued to emphasize the need for health and wellness programs. Nevertheless, it has been reported that 70% of fire departments still don't have established programs (Storer et al., 2014). Suboptimal fitness and excess body weight can have negative consequences with the high-energy demands required by firefighters, a combination that may provide a trigger for sudden line-of-duty cardiovascular or cerebrovascular events (Storer et al., 2014).

The NFPA annual report found cardiovascular disease (CVD) is responsible for nearly 50% of on-duty firefighter fatalities (NFPA, 2022). One study of a group of 270 firefighters in an established wellness program found that 77% of the participants were overweight or obese (BMI), and 76% had a moderate to very high risk of cardiovascular disease (CVD) (Lockie et al., 2021). Anthropometric measures are only one of many reliable CVD risk factors. Other factors such as higher cardiorespiratory fitness, muscular strength, and endurance that have been found to be positively associated with lowering the risk of CVD (Smith et al., 2023). Despite their risk

for CVD, most firefighters have been found to have higher fitness levels compared to the general population (Lockie et al., 2022). Although they were found to be more physically fit than the general population, the majority who participated were found to be at a higher risk for CVD, largely due to below-average body composition scores (Lockie et al., 2022). Considering the previous data, there is a possibility that excess body fat could be a main determining factor for physical fitness and health status in firefighters.

Improving body composition can have a positive impact on overall physical fitness status. Siddall et al. 2018 found firefighters in the lowest quintiles for fat mass performed the fire-simulated circuit quicker than both the overall average and those in the highest quintiles for fat mass. Another study found high performance on several fitness parameters: upper-body strength, abdominal strength, upper-body muscular endurance, and anaerobic power were shown to be related to high performance on a simulated firefighting task (Michaelides et al., 2011). More specifically, poor performance on simulated fire tasks was associated with high resting heart rate, high body mass index, high body fat (BF)%, and large waist size (Michaelides et al., 2011). Excess BF can put additional stress on the heart, which is even more of a concern for firefighters due to the physiological stress associated with the job. Ras et al. (2022) found lean body mass and grip and leg strength were significantly related to physical activity test (PAT) tasks and total completion time. Michaelides et al. (2011) supports these findings, showing increasing muscular strength/endurance and decreasing BF are two great methods for improving performance in FST, which can be simplified as an increase in muscle mass. Since firefighters are required to carry heavy PPE and have to lift things in very uncomfortable/unsafe situations, increasing muscular strength, power, and endurance should be a priority. To achieve improved fitness, having

evidence-based programming tailored to the needs of the firefighters can significantly improve overall health and performance in the department.

When the goal is to improve health & fitness status, periodization is the first step in establishing how to meet the needs of the population. Periodization is a planned variation of acute program variables that have been shown to be more effective in eliciting strength and body mass improvements than non-periodized programs (Rhea et al., 2002). Different periodization methods can be used to elicit specific training adaptations to achieve those certain goals. Traditional or linear and undulating or non-linear periodization are two of the most common training program designs. Linear periodization (LP) divides a strength training program into different periods or cycles: macrocycles (9-12 months), mesocycles (3-4 months), and microcycles (1-4 weeks), gradually increases the training intensity while decreasing the training volume within and between cycles (Prestes et al., 2009). Daily undulating periodization (DUP), which consists of increasing and decreasing intensity and volume, with the alterations occurring within the same week; that is, the variation of training components is more frequent and lasts for a shorter period (Prestes et al., 2009). There is a lack of research that investigates which method shows better results, especially relating to firefighter fitness and performance. Rhea et al. (2002) examined how 20 trained men responded to either LP or DUP, and they found significant increases in strength for bench and leg press for both training groups. The DUP group experienced significantly greater percent gains in strength from T1 (Baseline) to T2 (6-weeks post-baseline) and from T1 to T3 (Post-test) ($p >$, 0.05) compared with the LP group (Rhea et al., 2002). Another study examined how both muscular strength and endurance changed in 20 trained men, 10 assigned to LP and 10 assigned to DUP, during a 10-week training program where each

group completed 3 training sessions a week. They found no significant difference between the two groups for both strength and endurance, however they did find that the effect size presented moderate post-test strength and local muscular endurance gains in favor of the DUP (Rodrigues et al., 2018).

There is very limited research that examines how different periodization strategies affect occupational performance in firefighters. Most research analyzing the differences between program effectiveness focuses on different populations in the general public and athletes in some studies. Only one study to date exists exploring the difference between training programs specifically for firefighters. Peterson et al. (2008) observed a difference between programming effectiveness in improving overall fitness and job-specific tasks specifically in firefighters. They found that all fitness and job-specific task (Grinder test) performances increased for both training protocols, however, the UT group experienced significantly greater improvements ($p < 0.05$) in Grinder performance than the standard training group. UT demonstrated greater general improvements in many of the administered tests, including upper-body muscular strength, lower-body muscular strength, power production (PP) output at 30% 1RM, average and PP output at 60% 1RM, and vertical jumping ability (Peterson et al., 2008). When looking at the literature, regardless of the population, both training protocols showed improvements in overall health, fitness, and performance.

Although research is emerging on the different training periodization for firefighters, more studies are needed on how different periodization strategies affect strength and power in firefighters and the impact that has on occupational performance. The purpose of this study is to

evaluate the effectiveness of an 8-week undulating training program on rural firefighter body composition, muscle fitness, and occupational performance.

RESEARCH QUESTIONS and HYPOTHESIS

The present study was guided by three overarching research questions exploring training periodization in firefighters. These research questions were:

R1: What is the effect of an 8-week undulating training program on firefighter body composition?

H1 null: No differences will be observed in body composition following the 8-week program.

H1 alternative: There will be a significant improvement in body composition following the 8-week program.

R2: What is the effect of an 8-week undulating training program on firefighter muscular strength and power?

H2 null: No differences will be observed in muscular strength and power among participants following the 8-week program.

H2 alternative: There will be a significant improvement in muscular strength and power following the 8-week program.

R3: What is the effect of an 8-week undulating training program on firefighter occupational performance?

H3 null: No differences will be observed in time to complete occupational tasks among participants following the 8-week program.

H3 alternative: There will be a significant improvement in time to complete occupational tasks following the 8-week program.

Chapter 3

METHODS

Experimental Approach to the Problem

This quasi-experimental study examined the effects of an 8-week undulating training (UT) program on firefighter body composition, strength/power, and fire suppression task (FST) performance. The independent variable of the study is the 8-week undulating program. The dependent variables included weight (WT), body fat percentage (BFP), muscle mass (MM), hand grip strength (HGS), counter-movement jump (CMJ), and occupational performance.

Participants

A convenience sample of 33 full-time firefighters from the southeastern United States were recruited for participation in this study. The participants were all male and had an age range from 19 to 52 years old. Inclusion criteria included being 18 years of age and being a full-time firefighter. Exclusion criteria included anyone with existing or new injuries. Before data collection, participants were informed about the study procedures, requirements, and risks. Participants signed an informed consent form before testing. Institutional Review Board approval was obtained prior to data collection (H19698).

Procedures

One week prior to the start of the 8-week UT program, all participants were tested on their performance on several fitness variables including WT, BFP, MM, CMJ, HGS, and FST performance. Pre data was collected during the week prior to the program beginning during their normal physical training time at 0800, and the body composition was collected before dinner to

ensure a four hour fast. Following the collection of this data, participants started an 8-week UT program, which was led by peer-fitness instructors appointed by the department and monitored by certified graduate assistants assigned to the department. Prior to the start of the program, all peer fitness instructors approved of the program and were guided through the program beforehand. Post-testing on all fitness variables were retested starting day 1 of week 8 to see if there were statistically significant changes from the pre-to-post UT program. Post-testing was done an hour before dinner to ensure each participant was 4-hours fasted prior to the recording of data.

8-Week UT Program

The program was divided into three phases: accumulation, transmutation, and realization. The goal of the accumulation phase is to maximize strength and power improvements for 4-weeks. Next, participants enter the transmutation phase, which focuses on muscular endurance and cardiovascular endurance in a circuit-based workout for three weeks. Lastly, the realization phase used specific simulated fire suppression tasks and the 8th week for active recovery. Each week consisted of two to three training sessions, each with a distinct purpose (strength, power/dynamic, mobility). The department employing participating firefighters is divided into three shifts (A, B, and C). Each shift completed Day 1 (Strength) and Day 2 (Power/Dynamic), while only one shift got to complete Day 3 (Mobility) each week. Each training session started with a 5–10-minute warm-up, followed by 30-40 minutes of the main training, and finished with a 5-10 minute cool down. The training sessions were supervised by peer fitness instructors appointed by the department and one or two graduate assistants were present for extra assistance as well. Figure 1 displays an example of the accumulation phase, followed by Figure 2 which

displays an example of the transmutation phase, and lastly Figure 3 displays an example from the realization phase.

Figure 1

Accumulation Phase (Maximal Strength/Power)

Week 1				
Day 1		**Day 2**		**Day 3**
Strength Development		**Power / Dynamic**		**Mobility**
Quad Ped - Cat and Cow		Knee Hugs/ Quad Pull/ Scoops		Roll Down - hang
Worlds greatest stretch		Worlds greatest stretch		Roll Down: walk to plank
1/2 Kneeling Quad stretch		Hip open/close		Roll:Plank: Spider Step - rock it
Scap Push Up		Bridges		Roll:Plank:Spider: T Spine Stretch
Deep squat with t spine rotations		Leg swings		Roll:Plank:Spider:TSp: PU
Push up to downward dog		Plank		Roll:Plank:Spider:TSp: PU: Cobra
Bridge- double or SL		Fast feet		Quad Ped
				Cat-cow
*Goblet Squat	5*5	**FULL BODY**	5 Sets	Child Pose
a) Lateral Lunge 8 total 4 each		Trap Bar Deadlift 70%	5	Thread the needle
b) Deadbugs 8 total 4 each		Repeated Broad Jump	5	Quad Ped Kick Stand Child Pose
*Bench Variation: Bench	5*5	Push Press with Lt bar	5	Standing Series
a) Face pulls 8 reps		Accelerated KB Swing - Partner	5	3 Way ankles
b) Tricep - 8 reps		Recover: 2 in 4 out breaths		SL Stance hold
*Pull Variation: Row	5*5	HR needs to be recovered		SL - Track Start
a) Biceps Curls - fast 10				**Lunge Series - Foam Roll / Wall**
b) TY's split stance - 8 total				Bow and Arrows
* Warm up set 1 at 8-10 rep and 1 at 6-7 reps		Stability		Reverse wall angles
		3 Way Ankle 4 each side		
		3 way ankle add PU -2 lat/back		**30 Minute of Movement**
		Track Starts		Run, Walk, Bike, Swim
		Plank		
		Crocdile walk 4 forward /back		

Figure 2

Transmutation Phase (Strength Endurance)

Week 5				
Day 1		**Day 2**		**Day 3**
Full		**Full**		**Mobility**
EZ Jog to the Side walk and back		EZ Jog to the Side walk and back		Roll Down - hang
Dynamic Warm up		Dynamic Warm up		Roll Down: walk to plank
Worlds greatest stretch		Hip open/close		Roll:Plank: Spider Step - rock it
Deep squat with t spine rot		SL RDL		Roll:Plank:Spider: T Spine Stretch
IWTYs		Leg swings		Roll:Plank:Spider:TSp: PU
air front squat		Push up to downward dog		Roll:Plank:Spider:TSp: PU: Cobra
				Quad Ped
				Cat-cow
30 work : 30 rest/transition	16 min	30 work : 30 rest/transition	16 min	Child Pose
Med Ball Slam		Sandbag power clean		Thread the needle
Goblet front squat KB		SL DL with KB		Quad Ped Kick Stand Child Pose
Sandbag rows		1/2 kneeling Press		Standing Series
Bridge -		Plank Opens Ups		3 Way ankles
	4 rounds		4 rounds	SL Stance hold
20:10 sec Work to Rest , 4 sets 1 min recovery; next set	**12 mins total**	20:10 sec, 4 sets 1 min recovery; next set	**12 mins total**	SL - Track Start
CM Jumps	4 sets	Split Squat Jumps	4 sets	**Lunge Series - Foam Roll / Wall**
Line Drills	4 sets	Jump Rope	4 sets	Bow and Arrows
Sprawls (beginner burpee)	4 sets	BEAR Crawls	4 sets	Reverse wall angles
Lateral shuffles	4 sets	5-10-5 drill	4 sets	**30 Minute of Movement**
				Run, Walk, Bike, Swim

Figure 3

Realization Phase (Occupational Fitness/Active Recovery)

Day 1		Day 2		Day 3
Pre Game		**Fire Suppress Task**		**Mobility**
Knee Hugs/ Quad Pull/ Scoops		Knee Hugs/ Quad Pull/ Scoops		Roll Down - hang
Worlds greatest stretch		Worlds greatest stretch		Roll Down: walk to plank
Scap Push Up		Scap Push Up		Roll:Plank: Spider Step - rock it
Deep squat with t spine rotations		Deep squat with t spine rotations		Roll:Plank:Spider: T Spine Stretch
Push up to downward dog		Push up to downward dog		Roll:Plank:Spider:TSp: PU
Air Squat		Air Squat		Roll:Plank:Spider:TSp: PU: Cobra
Squat Jumps		Squat Jumps		Quad Ped
				Cat-cow
		Forceable Entry		Child Pose
Stair Climb		Stair climb high rise pack		Thread the needle
Pike Pole Pulls		Ceiling Breach		Quad Ped Kick Stand Child Pose
Keiser Sled / Tire Hits		Hose Adv		Standing Series
Hose Drag		Search crawl		3 Way ankles
Dummy Drag		Victim drag		SL Stance hold
Equipment Carry		Tool carry		SL - Track Start
				Lunge Series - Foam Roll / Wall
				Bow and Arrows
				Reverse wall angles
				30 Minute of Movement
				Run, Walk, Bike, Swim

Measurements

Body Composition

To assess total body composition, the DC-430U Dual Frequency Total Body Composition Analyzer by Tanita was used with participants (Tanita Corporation of America, Inc., Arlington Heights, IL, USA). Weight (WT), body fat percentage (BF%), and muscle mass (MM) were recorded by Tanita BIA. Each participant was instructed to have fasted for three to four hours before data collection to ensure an optimal BIA analysis (Body Composition Analyzer DC-430U Instruction Manual).

Muscular Fitness

To assess upper body strength, participants tested their grip strength with both hands using a Jamar Hydraulic Hand Dynamometer. Participants were instructed to keep their arm at a 90-degree angle while applying maximum force to the dynamometer (JLW Instruments, Chicago, IL, USA). Each participant was given three attempts for both dominant and non-dominant hand. The best of the three attempts were recorded. To assess lower body strength/power, participants performed a countermovement jump on a Just Jump System jump mat (Perform Better, West Warwick, RI, USA). Participants were instructed to descend into a half squat and then explode out of the half squat into a maximum effort jump, ensuring to land with both feet on the mat. Arms were free moving during each trial. Participants were given three attempts, with the best of these three recorded.

Occupational Task

The completion of a standardized set of fire suppression drills was timed with a stopwatch. Firefighters were instructed to complete the tasks as quickly as possible at an occupational pace, similar to what they would do at a fire scene. First, firefighters ascended three flights of stairs while carrying a high-rise pack (30.5 m hose; ~67.3 kg) on their shoulders and placed the pack on the landing after descending back down the stairs. Firefighters then proceeded to the Ceiling Breach station where twenty repetitions of pushing and pulling movements against 18.2 kg resistance using a 1.83 m pike pole on a ceiling breach and pull simulator were performed. Then, firefighters walked to a roof ventilation station where a 4.1 kg sledgehammer was used to strike a 68.6 kg I-beam on a Keiser Force Machine to simulate a rook ventilation task. The I-beam was struck until it moved at the end of the platform. Next, firefighters walked to

a Victim Rescue station, where they dragged a 75 kg mannequin to a cone 7.62 m away and returned to the starting position (total distance: 15.2 m). Then, a hose attached to a small tire was dragged approximately 6.1 meters and subsequently returned to the starting position. Finally, firefighters walked and completed an equipment carry task by carrying two 12 kg kettlebells, approximately 6.1 meters, then turned around and returned to the start.

Data Analysis

The independent variable for this study is the 8-week undulating training program. The dependent variables in this study include pre and post data, which includes BF%, MM, weight, HGS, CMJ, and FST performance. The independent effects of the undulating program on firefighter fitness variables were assessed with paired sample *t*-tests for normally distributed data. For significant findings, effect sizes were calculated using Cohen's d with the level of significance set at $p < 0.05$. All data sets were analyzed using IBM® SPSS® Statistics 27 (IBM Corp., Chicago, IL) software.

Chapter 4

RESULTS

Demographics

A total of 33 active full-time male firefighters completed the 8-week training program and were included in the statistical analyses. The mean average age for participants was 29.18 years (SD 8.49), mean average height was 180.95 cm (SD 2.69), and mean average years of service was 6.98 years (SD 7.08). Using descriptive analysis, all variables were converted to normative values using z-score to identify any potential outliers. Excluding outliers, all 33 participants who completed the program were included in the statistical analysis for all variables.

Body Composition

Table 1 displays the descriptive statistics for all body composition variables from pre- to post-testing. Analysis of body composition variables showed from pre- to post-testing, there was a statistically significant increase and moderate effect size in WT ($p = 0.002$, ES = 0.547). There was also a statistically significant increase, with a low to moderate effect size for MM ($p = 0.022$, ES = 0.371) and BFP ($p = 0.021$, ES = 0.374). Table 1 also displays the comparison of body composition variables from pre- to post-testing using a paired sample *t*-test.

Fitness

Table 1 displays the descriptive statistics for all fitness variables from pre- to post-testing. Analysis of fitness variables demonstrated a statistically significant increase and low-to-moderate effect size in both DOM HGS ($p = 0.023$, ES = 0.363) and NON-DOM HGS (*p*

= 0.025, ES = 0.356). A statistically significant decrease and moderate effect size were found in FST performance time (p = < 0.001, ES = -0.597). CMJ showed no statistically significant differences and a low effect size (p = 0.464, ES = -0.016). Table 1 also displays the comparison of muscular fitness variables from pre- to post-testing using a paired sample *t*-test.

Table 1

Descriptive and Paired Sample t-test Statistics for Fitness Variables

Test	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	p-value	Effect Size
Weight, kg	93.3 ± 18.2	94.2 ± 17.84	0.002	0.547
Muscle Mass, kg	68.3 ± 7.1	68.5 ± 7.1	0.022	0.371
Body Fat, %	21.76 ± 7.5	22.5 ± 7.6	0.021	0.374
Dominant Grip Strength, kg	57 ± 7.02	58.9 ± 9.02	0.023	0.363
Non-Dominant Grip Strength, kg	54.4 ± 9.01	57 ± 10.4	0.025	0.356
CMJ, cm	50.9 ± 9.14	50.9 ± 11.23	0.464	-0.016
FST, s	240.1 ± 71.9	221.7 ± 54.4	0.001	-0.597

Note. One-tailed significance set at p < 0.05 with a 95% confidence interval. CMJ: Countermovement jump, FST: Fire suppression task

Chapter 5

DISCUSSION

This study aimed to evaluate how an 8-week undulating training program would affect body composition, muscular strength/power, and occupational performance in a local southeastern fire department. Undulating programs give participants the ability to modify intensity and volume daily. Considering the variability of the workload and timing of the profession, firefighters cannot predict the level of fatigue endured on any given day. Therefore, an undulating training program can be very useful in improving firefighters' overall fitness and occupational performance.

The main finding of this study was that an 8-week undulating training program may help increase firefighter MM, as well as improve muscular strength and occupational performance. Although research analyzing effects of an undulating program on firefighters is scarce, results from this current study are in accordance with previous work, showing the positive effects of an undulating program on firefighter fitness and occupational performance (Peterson et al., 2008). This similarly aligns with previous work involving the common population, also showing results favoring UP over other types of programming such as LP (Molina et al., 2022) (Prestes et al., 2009).

This study showed a statistically significant increase in WT, MM, and BFP with low-to-moderate effect sizes (Table 2). Considering the effect sizes of MM and BFP, it would seem that the significant increase in WT could be equally caused by an increase in both MM and BFP (Table 2). A nutritional intervention was not implemented in this study, so the causation for the increased BFP cannot be explained. These findings are partially supported by Prestes et al. 2009,

who found a significant increase in fat-free mass (FFM), however a significant decrease in fat mass (FM) in women. Another study comparing LP and UP in older adults showed a significant increase in FFM with no significant differences in FM (Molina et al., 2022). Since the goal of the program was to increase strength and power, the increases in WT and MM align with the researcher's expectations. However, another study comparing LP and UP found a significant increase in strength/power, with no significant increase in body mass (Peterson et al., 2008).

For the fitness variables, there was a statistically significant increase in both dominant and non-dominant HGS, with low-to-moderate effect sizes (Table 4). This finding is supported by Molina et al. 2022 who found a significant increase in overall strength, tested by a hand dynamometer, following an 8-week undulating program. Considering the increase in MM, there is a possibility that this may have been a factor in the increase of HGS. One study exploring overall strength in children and young adults found HGS to be a reliable method for measuring total body strength (Wind et al., 2010). A statistically significant difference was not observed for CMJ in this study (Table 4). The findings from the strength/power variables are partially supported by Peterson et al. 2008, who found a significant increase in both 1RM squat (strength) and vertical jump (power).

The largest statistically significant difference was demonstrated for FST times (Figure 4). The FST course used is arguably the most relevant variable since it is designed to replicate many of the tasks seen in this occupation. This finding is supported by Peterson et al. (2008), who compared UP to a standard training protocol on firefighter job performance, and a significant difference was observed for both groups, with much greater improvements in the UP group. Due to the variability of the job, an undulating program could be an optimal choice considering the

freedom to alter exercise selection and intensity daily. Firefighters need to stay physically fit in order to optimally perform on shift, however having a flexible training program to accommodate any unforeseen circumstances could be the more efficient choice.

Limitations

There were a few limitations to this study. Although the program was monitored by graduate assistants daily, there could be a concern when assessing effort during training sessions. Each session was intended to be performed with maximum intensity which can be difficult to achieve due to factors such as occupational fatigue or attitude towards the program. In addition, percentages were given for all lifts to ensure each participant knew how much weight they should use. This could cause issues if participants were lifting too light or heavy in order to match other participants in their respective groups. Outside training was not controlled for this experiment which could raise concern for overtraining, thus hindering performance during both on-shift training and post-testing. The timing of post-testing could have also played a role in the outcome, considering the participants were post-tested the same week of their FST. Although they were given adequate time to rest and recover, the participants could have still been experiencing some level of fatigue. In addition, to receive optimal results from the TANITA, one should be fasted for at least 3-4 hours prior to the body scan. Since the post-testing was done later in the day while the participants were on shift, it was not feasible to have them all fasted prior to testing. Even with optimal testing conditions, BIA raises potential risks for errors as it is not considered the “gold standard” for assessing body composition. In addition to potential errors, small fluctuations in weight throughout the day are very normal, which could explain the

increase in weight considering post-testing was completed later in the evening. Also, not having a nutritional intervention could have had a negative impact on the results. Due to the intensity of the program, participants could have seen an increase in hunger, which could have had an impact on the increase of BFP. Dietary intake is directly correlated to body composition and improving overall fitness, so although we saw positive significant changes, the improvements might have been greater with some form of dietary intervention and/or monitoring. Lastly, the biggest limitation in the study was the absence of a control group. Even though we saw a significant improvement for a majority of the variables, we cannot confidently conclude that the UP explained the outcomes in this study. Future research should pursue nutritional interventions in combination with training interventions to explore the potential impacts on fitness and performance variables.

Practical Applications

There are several practical applications that can be gathered from this study. The present study demonstrated that UP had a statistically significant impact on firefighter body composition, strength/power and occupational performance. Considering the difficulty of the occupation, improving body composition and fitness are crucial to improving firefighter performance and reducing injury risk. Departments can use the findings in this study to create and implement their own health and wellness programs. UP allows departments to implement a program that can be altered daily depending on the level of fatigue present in firefighters. Future research should focus on improving firefighter health, fitness, and performance through exercise programming to find the most optimal training interventions. Not only will these findings benefit firefighters, but

the generalized application may benefit non-firefighter citizens as well. Firefighters are faced with the task of saving peoples' lives every day in varied and extremely dangerous scenarios, thus ensuring these brave men and women are optimally prepared is of the importance to everyone.

Conclusion

Being physically fit is crucial to the safety and performance of being a firefighter. Being physically unfit is not only dangerous for the firefighter, but all civilians whose lives might depend on it. UP has been shown to improve firefighter fitness and performance through the current study, as well as others. These findings display the importance of training programs for the preparedness of firefighters and why more departments should investigate establishing their own programs.

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