



Does Body Mass Index Influence the Physiological and Perceptual Demands Associated with Defensive Tactics Training in State Patrol Officers?

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ABSTRACT

International Journal of Exercise Science 11(6): 319-330, 2018. The purpose of this investigation was to determine the physiological and perceptual demands associated with defensive tactics (DEFTAC) training among state patrol officers of different BMI (body mass index) categories. Twenty-four male state patrol officers ($n = 24$, age 36.00 ± 7.86 yrs) voluntarily agreed to participate in data collection during a DEFTAC gauntlet. Anthropometric information (height (HT) 182.19 ± 7.43 cm and weight (WT) 96.31 ± 17.45 kg), body mass index (BMI), peak and average heart rates, duty weight, BLa, and RPE, were recorded. Officers were then divided into two-groups (Healthy BMI (BMI ≤ 25), $n = 12$, Overweight (BMI ≥ 25), $n = 12$). Analyses of covariance (ANCOVAs) were conducted to determine the effect of BMI on the outcome variables. Furthermore, a Pearson's product-moment correlation coefficient was also conducted to determine if significant relationships between RPE, BLa, and HR existed between groups. Significant mean score differences between healthy and overweight officers were found in measures of age [$t(22) 4.12, p \leq 0.01, R^2 = .44$], and weight of duty gear [$t(21) 3.96, p \leq 0.01, R^2 = .33$]. When used as a covariate, age also predicted average HR% [$F(1, 21) = 6.19, p < .05, \text{partial } \eta^2 = .24$]. Significant relationships were found in the healthy group between RPE and DEFTAC time, DEFTAC time and score, as well as score and post BLa. Significant relationships for the overweight group between peak (HR) percentage and post BLa, peak (HR) percentage and RPE, DEFTAC time and duty weight, and between weight and DEFTAC time. The results of this study suggest that overweight officers may have lower DEFTAC scores when compared to their healthy counterparts. Based on the results, it seems reasonable to compare physiological variables from this population to those from combative sports as well as for officers to achieve and maintain a healthy BMI value in order to improve individual DEFTAC performance.

KEY WORDS: Law enforcement, police, defensive tactics, use of force, combatives, Body Mass Index

INTRODUCTION

As part of their normal duties, law enforcement officers are required to resolve conflicts that cause a threat to public safety. In certain instances, such as self-defense, compelling an unwilling subject to yield, or when the public is in immediate danger, use of physical force may be necessary to maintain public and personal safety (18). For these reasons, Defensive Tactics and

Arrest Control (DEFTAC) training is required by law enforcement agencies. At this time, there is no published data regarding the physiological and subjective demands of DEFTAC scenarios within this population. However, it is known that physical performance is affected by body mass index within basic military training and that having a lower work capacity may limit the overall work ability of less-fit subjects (19).

Body Mass Index (BMI) is an anthropometric measure used to assess body mass in relation to height. BMI is calculated using the Quetlet index, which is calculated by dividing bodyweight in kilograms by height in meters squared (kg/m^2) (1). BMI has been a method used to characterize physical condition and cardiovascular risk in this population (7). In a study by Estevez et al. (7) it was discovered that while the average officer's BMI were classified as mildly obese ($28.6 \pm 4.8 \text{ kg}/\text{m}^2$), it did not appear to negatively influence aerobic power or measures of muscular endurance. In contrast, Dawes et al. (4) found that BMI had a low significant correlation ($r = -0.448, p \leq .05$) to pull-up performance among members of a part-time SWAT team. In addition to the health and performance implications associated with BMI it is possible that individuals with high BMI scores (> 25) may also have an increased physiological burden when compared to those with lower BMI ratings (< 25). This may have significant implications should officers be required to defend themselves.

As previously mentioned, there is a scarcity of information available regarding the physiological demands of DEFTAC training among law enforcement officers. Based on the nature of this training, several comparisons between DEFTAC training and certain combative sports, such as judo, taekwondo, and wrestling, appear reasonable. These combat sports all involve body-to-body contact and rely heavily on the aerobic and glycolytic pathways during a match or competition (2, 10), similar to what has been observed in the DEFTAC training evaluated in this research.

Several authors have investigated the physiological stress associated with combative sports (2, 5, 10 13). Hernández-García et al. (10) discovered that Judo athletes achieved heart rate values between 85-90% of the participants' age-predicted maximum heart rate (APMHR) and had blood lactate concentrations between 9 to 24 mmol/L during national and international judo competitions. Similarly, Bridge et al. (2) observed that during competition, taekwondo athletes had heart rates between 175 ± 15 to 187 ± 8 beats per minute, while some athletes achieved heart rates as high as 100% of their APMHR. Furthermore, mean post-competition blood lactate concentrations were as high as 11.9 ± 2.1 mmol/L (2). Marrero-Gordillo et al. (13) found similar mean blood lactate concentrations (11.8 ± 2.6 mmol/L) after confrontations between two high level Canarian wrestlers. Likewise, Drid et al. (5), noticed blood lactate concentrations of 8.06 ± 2.35 mmol/L, 11.10 ± 2.28 mmol/L, and up to 15.55 ± 4.05 mmol/L among groups of male national wrestlers after competition.

In addition to a lack of information regarding the physiological intensity of DEFTAC training, no research is currently available related to the perceived exertion for this activity. However, perceived exertion in relation to several combative sports have been investigated (2, 14, 17). Bridge et al. (2), found increases in RPE (11 to 14 [6-20 scale]), age-predicted maximal heart rate

(APMHR) (89% to 96%) and blood lactate (7.5 to 11.9 mmol/L) from rounds one to three for a sample of black belt taekwondo athletes participating in international competition. Research by Nilson et al. (17) revealed mean blood lactate concentrations of 14.8 ± 2.8 mmol/L alongside a mean RPE of 13.8 among wrestlers competing in the 1998 World Championships. Although physiological markers of the stress response to exercise (such as heart rate and blood lactate) are linked to RPE in healthy subjects (14), it is unclear as to how connected these variables are in the law enforcement population during DEFTAC. Therefore, evaluating RPE, alongside heart rate and blood lactate, may provide a more complete picture of the perceptual and physiological demands of DEFTAC within the law enforcement population.

By gaining a greater understanding of the demands associated with this form of training, strength and conditioning professionals and law enforcement personnel may be able to better assess the related physical stress of DEFTAC training. This information may be useful in the development of structured training programs to improve performance in similar tasks. It is our hypothesis that since the biomechanical, physiological, and metabolic specificity of these sports are relatable to DEFTAC training, they provide a worthy base of comparison. Nevertheless, we speculate that the perceived demands of DEFTAC are reasonably comparable to the demands of the combative sports previously mentioned.

The authors also hypothesize that individuals with higher BMI's may experience greater physiological stress and have higher RPE's due to the increased burden of moving a larger mass. Therefore, the purpose of this investigation was to determine the physiological and perceptual demands associated with DEFTAC training among state patrol officers of different BMI categories. A secondary goal was to determine the relationships between HR, $\dot{V}O_2$, and RPE associated with this form of training.

METHODS

Participants

Twenty-four (n=24) male highway patrol officers (age = 36.00 ± 7.86 yrs; height = 182.19 ± 7.43 cm; weight = 96.31 ± 17.45 kg) voluntarily agreed to participate in this study. Prior to the commencement of this research approval was granted by the University of Colorado-Colorado Springs Institutional Review Board for human subjects. Informed consent was obtained prior to testing for all participants.

Protocol

Testing was performed at in the patrol training academy gymnasium, on a hardwood court. The measurements analyzed in this study were collected in the following order:

Height and Weight Measurements: Height (cm) and weight (kg) measurements for incumbents were measured using a digital scale (Health-O-Meter®, McCook, IL, USA) and a portable stadiometer (Seca®, California, USA). Prior to these measurements being collected all officers were asked to remove their shoes.

Heart Rate (HR) monitoring: Immediately after height and weight measurements were collected officers were provided with a Polar FT7 Polar heart rate monitoring device (Polar Electro Inc., Lake Success, NY). Officers were instructed to put on the strap and wristwatch per the instructions provided by the manufacturer. This data was compared to the individual officers age predicted maximum heart rate (APMHR) to estimate exercise intensity during the event.

Duty Weight: Once the HR monitors were in place, officers were asked to put on their personal protective gear and uniform. They were then reweighed to determine their duty weight. Officers were required to perform the DEFTAC gauntlet in this attire.

Blood lactate (BLa): Just prior to performing DEFTAC training blood lactate samples were collected via a fingertip capillary blood sample and analyzed with a portable lactate analyzer (Lactate Plus, Sports Resource Group, Inc.). Post blood samples and lactate readings were taken within 2- 3 minutes post DEFTAC training in the same manner as the pretesting protocol.

Defensive Tactics (DEFTAC) Gauntlet Drill: The overall purpose of the DEFTAC Gauntlet drill utilized in this study was to evaluate an officer's ability to perform mandated techniques, as trained, under mounting physical stress. The test was designed to evaluate the subject's physical abilities, information retention under stress and cognitive abilities under stress. The exercise had multiple components and while each component was evaluated individually by subject matter experts selected by the police organization being studied. The subject's overall ability to perform defensive tactics as trained was the substantial question being evaluated.

DEFTAC Gauntlet Procedures: Once in their full duty uniforms all officers were provided a briefing that explained the components of the DEFTAC drill. Participants were then asked to wait in a room separate from the gymnasium area until they were selected to perform the drill.

Each station was oriented across the gymnasium from each other at a diagonal angle (Figure 1). Each participant completed the DEFTAC drill individually. Upon entering the training academy gymnasium, officers were required to run to the first station where they performed 50 straight punches into a punch shield held by a volunteer (Figure 2). The participant then ran to the next station where they were instructed to "stop" and close their eyes. On the command of "attack" the participant opened their eyes and was confronted with an "overhead knife attack" (Figure 3). After performing the appropriate defense technique, the participant immediately ran to the third station where they were required to perform 30 front kicks with a volunteer holding a "tombstone" pad (Figure 4).

Upon the completion of the kicks the participant ran to the next station where they were told to "stop" and close their eyes. Upon the command of "attack" they were presented with an attack on their holstered handgun. The participant was to make the appropriate "holstered-retention" defense (Figure 5). Participant then ran to station five where they performed 30 knee strikes while a volunteer again held a pad to receive the knees (Figure 6). Once all knee strikes were delivered, the participant then ran to the next station where they were told to "stop" and close their eyes. On the command of "attack" the participant opened their eyes and was met with an

“overhead blunt-object” attack (Figure 7). Upon the participant’s defense against the blunt object, they ran to the next station where they were instructed to lay down on their backs with arms and legs flat against the ground. They were told to “get up” in the “Defensive Recovery Position”, and recover to a standing position (Figure 8). The participants were then instructed to walk forward to the next station where they were again told to “stop” and close their eyes. Upon the command of “attack” they were presented with a handgun aimed to the front of their body (held by a volunteer) which should have elicited the appropriate handgun disarming technique (Figure 9). The participant was to order the attacker into a prone position where they could apply handcuffs as trained (Figure 10). The application of the handcuffs marked the end of the exercise. The entire event was timed from the command of “go” (at the southwest corner of the gym) to the final and complete application of the handcuffs (at the southeast corner of the gym). Four DEFTAC subject matter experts (SME’s), evaluated each of the following components: The subject’s ability to perform the techniques as trained; The subject’s intensity/speed while performing the technique; The subject’s physical ability to continue through the process; The overall success of the techniques demonstrated.

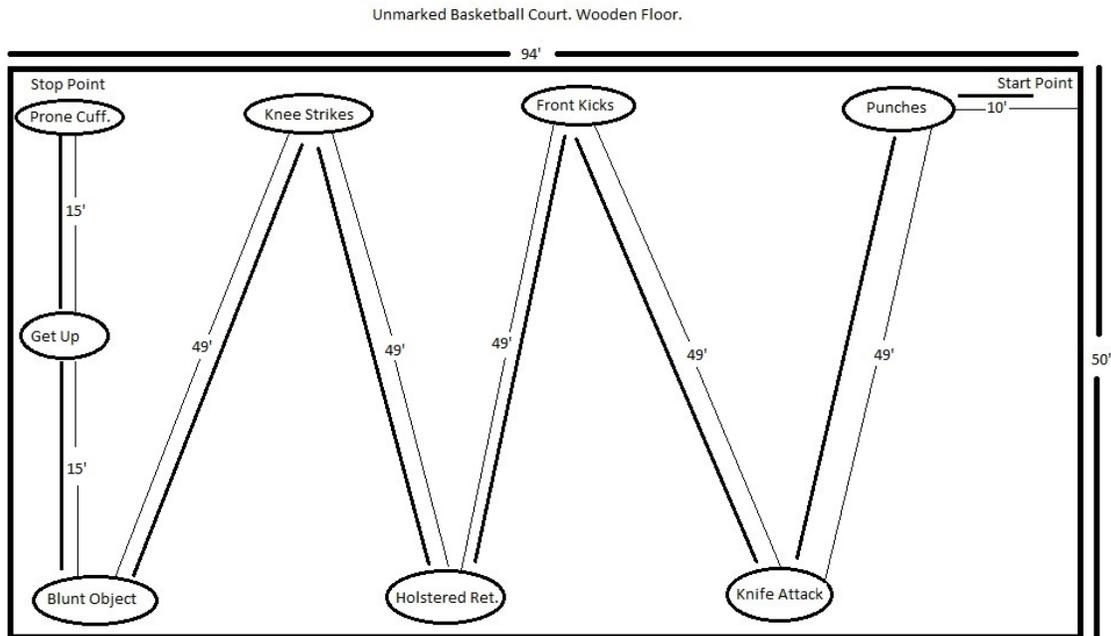


Figure 1. Gymnasium.

At the conclusion of the gauntlet each participant was given an overall pass/fail rating by four instructors. Scores were determined based on multiple aspects of performance, such as technique appropriateness of the technique selected, and relative intensity. The interrater reliability of the instructors was high, with a Cronbach’s α of .812. The investigators used this rating to determine an overall success rate, or score, by calculating the participants passing percentage. This score was determined based on the number of overall passes divided by the total number of ratings.



Figure 2. Straight punches.



Figure 3. Edged weapon defense.

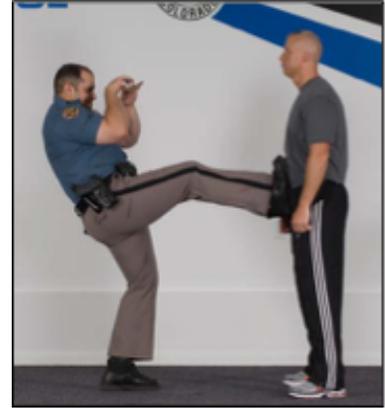


Figure 4. Front kicks.



Figure 5. Holstered weapon retention.



Figure 6. Knee strikes.

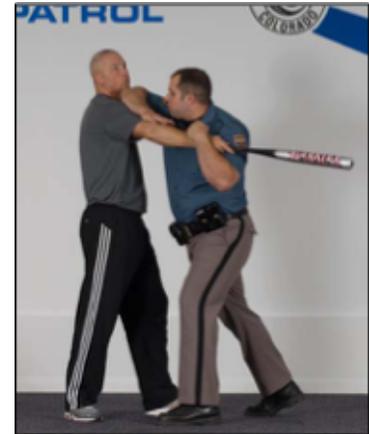


Figure 7. Blunt object defense.

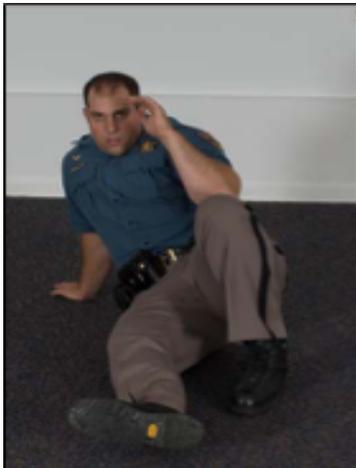


Figure 8. Defensive recovery.



Figure 9. Handgun disarm.



Figure 10. Prone handcuffing.

Rating of Perceived Exertion (RPE): Partipants rated the overall intensity of the activity using the OMNI Scale. Research has shown that this scale is a valid and reliable measure of exercise intensity and is comparable to the Borg Scale of Perceived Exertion (12,16).

Statistical Analysis

Collected data was entered into a computer file suitable for statistical analysis using the Statistical Package for Social Sciences (SPSS) 24.0. A descriptive statistical analysis was conducted to determine the mean scores and standard deviations for the total sample of officers related to anthropometric characteristics. Officers were then divided into two-groups (Healthy BMI, n = 12, Overweight, n = 12) (1). In order to ascertain the effect of BMI on the outcome variables of DEFTAC score, DEFTAC time, RPE, Average HR, Average % HR, Peak HR, Peak % HR, blood lactate before the test and blood lactate after the test, analyses of covariance (ANCOVAs) were performed using age in years as the covariate. This was done as there was a difference in age between the low and high BMI groups. The threshold for α was .05 for all analyses.

A Pearson’s-product moment correlation was also performed to investigate the relationships between the previously described variables. The alpha level for this analysis was set at an a priori of $p \leq 0.05$.

RESULTS

Descriptive results for each of the anthropometric, physiological and performance measures for each group are displayed in Table 1. Significant mean score differences between healthy and overweight officers were found in the measure of age [$t(22) = 4.12, p < .001, R^2 = .44$], and weight of duty gear [$t(21) = 3.25, p \leq .01, R^2 = .33$].

Table 1. Anthropometrics.

Measure	Healthy (n=12) Mean \pm SD	Overweight (n=12) Mean \pm SD
Age (yrs)	30.92 \pm 5.07 †	41.08 \pm 6.88 †
Ht (cm)	182.66 \pm 5.97	181.71 \pm 8.91
Wt (kg)	89.67 \pm 13.30	102.96 \pm 19.08
Duty wt (kg)	98.98 \pm 12.96	110.60 \pm 19.12
BMI	20.90 \pm 2.42	30.05 \pm 4.17
Duty gear (kg)	10.00 \pm 1.9 †	7.43 \pm 1.16 †

† Significant differences at $p \leq .01$

Ellis (6) interprets η^2 of .01, .06, & .14 as small, medium, and large effects respectively, and these effects will henceforth be interpreted along with the null hypotheses. The null hypothesis for the effect of the covariate age on average heart rate % was rejected $F(1, 21) = 6.19, p < .05$, partial $\eta^2 = .24$. Although all other null hypotheses were retained (Table 2), age had a medium to large effect on average heart rate, and PHR (%). Age had a medium effect on DEFTAC time, average HR, and blood lactate.

BMI had a large effect on RPE, and a medium effect on the DEFTAC scores and PLa. Wearing duty gear had medium effects on DEFTAC time, average HR, average HR % and the blood

lactate variables. Because of the number of medium effects of BMI, age, and weight of duty gear upon the dependent variables, this study was likely to be underpowered.

Table 2. Performance variables.

Measure	Healthy (n=12) Mean ± SD	Overweight (n=12) Mean ± SD	Effect size of BMI (partial η ²)	Effect size of age (partial η ²)	Effect size of duty gear (partial η ²)
DEFTAC Time (sec)	187.83 ± 23.52	185.41 ± 31.39	.01	.06	.06
DEFTAC Score (%)	97.92 ± 7.21	70.83 ± 36.67	.07	.03	.00
RPE	7.25 ± 1.36	6.41 ± 1.62	.13	.04	.00
Average HR (bpm)	155.41 ± 21.03	154.66 ± 17.84	.01	.09	.06
Peak HR (bpm)	180.08 ± 10.87	177.91 ± 9.89	.00	.04	.01
Average HR (%)	0.82± 0.12	0.87 ± 0.11	.01	.24*	.06
Peak HR (%)	0.95 ± 0.06	1.00 ± 0.59	.00	.09	.01
BLa PRE	2.17 ± 0.58	2.5 ± 0.65	.02	.07	.04
BLa POST	12.25 ± 2.5	10.75 ± 2.03	.07	.05	.07

*= $p < .05$

Significant relationships were observed in the healthy BMI group between measures of RPE and time to completion, time to completion and score, as well as between score and BLa post (Table 3).

Table 3. Relationships between measures of physical and perceived exertion and performance - healthy BMI group.

Variables	BLa Post	RPE	Time	Score
Time (sec)	-	.600*	1.00†-	-
RPE	-	1.00†	.675*	-
Score	.590*	-	.699†	1.00†
BLa Post	1.00†			

*= $p \leq .05$; †= $p \leq .01$

Significant relationships were also observed in the overweight BMI group between measures of peak % APMHR and Bla post, peak % APMHR and RPE, time to completion and duty weight, and between weight and time to completion (Table 4).

Table 4. Relationships between measures of physical and perceived exertion and performance - overweight BMI group.

Variables	Peak % APMHR	BLa Post	RPE	Time	WT	Duty Weight
Peak % APMHR	1.00†	.597*	.629*	-	-	-
BLa Post	.597*	-	-	-	-	-
RPE	.629*	-	1.00†	-	-	-
Time (sec)	-	-	-	1.00†-	-	.699†
WT (kg)	-	-	-	.675*	.675*	-
Duty Weight (kg)	-	-	-	.699†	-	1.00†

*= $p \leq .05$; †= $p \leq .01$

DISCUSSION

The aim of this study was two-fold. First, we sought to determine the physiological and perceptual demands of performing a DEFTAC gauntlet among law enforcement officers. Secondly, we sought to determine whether significant differences existed in the physiological and perceptual demands of defensive tactics training in state patrol officers based on BMI. This study is the first to investigate the relationship between these factors. By having a better understanding of how these factors interact, instructors can improve the design of DEFTAC training scenarios. Furthermore, having a thorough understanding of the physiological demands associated with this form of training may assist in the design of exercise training programs aimed at improving performance in these endeavors.

Based on data collected through the HR monitoring device, it was discovered that the average HR ranges for this activity ranged between approximately 82-100% of the participants APMHR. These ranges are comparable to those that have been seen in several combative sports competitions (2, 9). This HR range is generally considered to be consistent with working at or near the anaerobic threshold (20). Therefore, this data would suggest that the DEFTAC training activity featured in this research is highly reliant on the aerobic and anaerobic energy systems (9).

When comparing groups, it was discovered that on average the overweight group had higher average and peak HR's when compared to the healthy group. Though not statistically significant, differences did exist between healthy and overweight officers in relation to both average and peak heart rate measures. On average, overweight officers had higher average (approximately 6.10% greater) and peak (approximately 5.26% greater) HR's than officers in the healthy weight category. Charles et al. (3), also reported that higher BMI's were associated with increased levels of oxidative stress in police officers. Furthermore, higher BMI has also been linked to a decreased favorable HR profile (HR at peak exercise, HR recovery, chronotropic index, and increased resting HR). Therefore, it is recommended that officers strive to maintain a healthy BMI range and participate in regular cardiorespiratory training in order to improve overall health and increase work-capacity.

Blood lactate levels increased from 2.17 ± 0.58 to 12.25 ± 2.5 mmol/L in the lower BMI group while the overweight BMI category increased from 2.5 ± 0.65 to 10.75 ± 2.03 mmol/L. These levels are also consistent with those that have been observed in several combative sports competitions (10, 13). We speculated that officers in the overweight BMI category would experience higher BLa post event when compared to those that were in the healthy BMI group. However, this was not the case. Based on observation and subject matter expert feedback, the authors would posit that the reason for this may have been related to a reduction in intensity by the overweight BMI category in order to complete the gauntlet. This hypothesis is also supported by the slightly lower RPE ratings seen in the overweight group when compared to the healthy group.

Officers in both groups rated the intensity of this activity between 6-7 RPEs, respectively. Using the OMNI scale for RPE this corresponds to an exercise rating of “somewhat hard” to “hard” (16). Bridge et al. (2) reported taekwondo athletes rated participation in international competition within similar ranges (e.g, 11 to 14 on the Borg RPE Scale). This range also corresponds to a rating of “somewhat hard”. Based on these findings it appears that the perceptual demands of the DEFTAC gauntlet are consistent with combative sports. However, given the potential for real world ‘stress inoculation’ an officer’s RPE for a clinical training exercise may be somewhat skewed. Regardless, to optimize preparedness for such an event, officers should focus on the integration of training activities with similar intensity ranges into their conditioning programs.

When comparing groups, a low effect size was discovered between groups, with the overweight group providing a slightly lower RPE rating when compared to the healthy group. This is interesting considering that the overweight group appeared to be working at a higher exercise intensity based on their APMHR. This may be due to several factors. Murillo et al. (15) found that athletes’ perceived exertion in some cases may be inconsistent with their cardiovascular response during competition scenarios. These authors proposed that this may be due to the combined physiological and psychological point of view of the participant. Therefore, it is possible that one or both groups may have inaccurately estimated, or misreported, their true level of difficulty performing this task. Based on the data and personal observations, the authors speculate that the overweight group may have been slightly lower due to a reduction in their overall intensity in order to recover from brief high intensity bouts of activity required to complete this course. This reduced effort was also reflected in the SME ratings, and the lower overall scores observed in this group. It is also possible that this reduction in intensity explains the overall lower Bla post measurements in the overweight group.

The difference in DEFTAC scores were significant between the healthy (97.92 ± 7.21) and overweight BMI group (70.83 ± 36.67). This is consistent with previous research that shows a negative relationship between fitness and occupational performance among law enforcement officers (3, 8). In contrast, Estevez et al. (7) reported that officer’s classified as mildly obese did not seem to exhibit reductions in aerobic power or muscular endurance capabilities. Nonetheless, aside from performance, there may be significant health concerns associated with a BMI rating in this range. Based on these findings, it is recommended that officers strive to attain and maintain healthy BMI ranges for both health and performance purposes.

In conclusion, based on the findings of this study it is evident that the physiological demands of DEFTAC training are comparable to combative sports competitions, and require officers to work at or near their anaerobic threshold. Furthermore, it appears that an officers BMI level may have a significant impact on the physiological stress of completing these tasks and negatively impact performance and is further compounded by the overall duty load and uniformed weight. Training programs for officers should focus on improving anaerobic capacity and maintaining a healthy weight should be emphasized to optimize health and performance

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