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RELATIONSHIP BETWEEN PHYSICAL FITNESS MEASURES AND
OCCUPATIONAL PHYSICAL ABILITY IN UNIVERSITY LAW ENFORCEMENT
OFFICERS

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
College of Education
at the University of Kentucky

By

Annie Quinn Beck

Lexington, Kentucky

Director: Dr. Mark G. Abel, Associate Professor of Kinesiology and Health Promotion

Lexington, Kentucky

2012

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ABSTRACT OF THESIS

RELATIONSHIP BETWEEN PHYSICAL FITNESS MEASURES AND OCCUPATIONAL PHYSICAL ABILITY IN UNIVERSITY LAW ENFORCEMENT OFFICERS

Law enforcement on academic campuses can be a physically demanding profession. Law enforcement officers (LEOs) may be required to perform a variety of physical tasks. Identifying which physical fitness characteristics are associated with these tasks will guide the development of appropriate and effective exercise programs. Therefore the purpose of this study was to identify physical fitness and demographic characteristics associated with the occupational physical ability of university LEOs. Sixteen male LEOs (age: 33.1 ± 8.7 yr.; body mass: 87.2 ± 11.2 kg; height: 178.9 ± 7.9 cm) performed an officer physical ability test (OPAT) that simulated a foot chase of a suspect. In addition, the officers completed a battery of physical fitness tests that assessed aerobic and anaerobic capacity, muscular endurance, strength, power, flexibility, agility, and body composition. The OPAT was correlated with agility, upper body muscular endurance and strength, torso endurance, lower body power, aerobic endurance, and relative body composition ($p < 0.05$). In addition, the OPAT was correlated with the following demographic and anthropometric variables: age, work experience, and waist and abdominal circumferences ($p < 0.05$). In conclusion, tactical strength and conditioning professionals must design exercise programs for university LEOs to improve multiple components of physical fitness and focus on weight management.

KEYWORDS: Police, Law Enforcement Officer, Fitness, Exercise, Physical Ability

Annie Q. Beck

December, 11, 2012

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Chapter I

Introduction

Law enforcement on university or college campuses can be a physically demanding profession. Law enforcement officers may be required to perform a variety of physical tasks such as apprehending subjects, running up and down stairs, pushing their body over obstacles, dragging objects, and engaging in a foot chase. These tasks are performed while wearing personal safety equipment that weighs approximately 9 kg (e.g., vest, duty belt, side arm, etc.). In addition, these strenuous physical tasks are often performed after sitting in a patrol car for an extended period of time. Given the sporadic, yet physical nature of law enforcement tasks and the importance of performing these essential job functions successfully, it is critical that law enforcement officers achieve and maintain sufficient levels of physical fitness.

Although achieving maximal levels of all physical fitness components would be ideal, it is likely not possible to do so given the challenges of improving multiple performance outcomes with competing training stimuli (Rhea et al., 2008). Instead, it is important to identify specific physical fitness components that are associated with minimal competency for job performance of university law enforcement officers. This information would provide university or college law enforcement departments with information regarding the most appropriate type of physical fitness assessment(s) for recruits or incumbent officers. Furthermore, this information would provide incumbent officers, basic training officers, officer recruits, and tactical strength and conditioning

professionals with specific physical fitness components to target as part of the officers' physical training program to more effectively prepare officers for job tasks.

There have been a few investigations that have identified predictors of law enforcement physical ability (Rhodes & Farenholtz, 1992; Stanish, Wood, & Campagna, 1999; Strating, Bakker, Dijkstra, Lemmink, & Groothoff, 2010). These investigations have reported that a large variety of variables are correlated to law enforcement performance including anaerobic and aerobic capacity, upper body muscular endurance, lower body power, agility, age and body mass index (BMI) (Rhodes & Farenholtz, 1992; Stanish et al., 1999; Strating et al., 2010). Unfortunately, these studies have not reported consistent findings regarding characteristics that predict law enforcement physical ability. These discrepancies may be due to the different law enforcement populations evaluated (e.g., Royal Canadian Mounted Police Officers vs. Dutch Police Officers) and differences in the physical ability tasks assessed (i.e., run test vs. occupation-specific physical ability test). Furthermore, there is a paucity of research focused on evaluating the performance of university law enforcement officers. Therefore the purpose of this study was to identify physical fitness and demographic characteristics that are associated with the task-specific performance of academic law enforcement officers. We hypothesized that aerobic capacity, muscular strength, agility, age, and body composition would be associated with the occupational physical ability of academic law enforcement officers.

Delimitations

This study was delimited to the following:

1. Male University of Kentucky LEOs between the ages of 24 to 51 years and are free of physical injuries.

Assumptions

This study had the following assumptions:

1. It was assumed that the LEOs provided maximal effort on all physical tests.
2. The Officer Physical Ability Test (OPAT) was a valid measure of occupational tasks.

Chapter II

Review of Literature

Introduction

The study of performance within the field of exercise physiology is often a focus. Performance can be viewed as the ability to perform athletic or occupational tasks. Due to the critical nature of their job, Law Enforcement Officers (LEO) represent an important category within this area. Law enforcement officers' performance could be the matter of life or death for a civilian and the officer themselves. Law enforcement officers do not perform their job for a gold medal or a trophy; however, high caliber performance of these individuals can save lives. This is why the assessment of their physical performance might be positively impacted by information provided by occupational physiology research. There is limited research focusing on the evaluation of LEO's performance and what physical fitness components contribute significantly to the performance of law enforcement officers. The physical fitness testing methods used in police departments are quite outdated. New research would help develop physical ability testing and proper exercise prescription in this population. Additional research could help tactical professionals identify physical fitness characteristics that are correlated to the job and determine what level of fitness officers must achieve to enhance officers' and civilians safety.

The general population has experienced a steady increase in obesity and decrease in physical activity (Flegal, Carroll, Ogden & Johnson, 2002). From 2009 to 2010, 35.7% of adults in the US were obese (Ogden, Carroll, Kit, & Flegal, 2012). Obesity is defined

as a body mass index (BMI) greater or equal to $30 \text{ kg}\cdot\text{m}^{-2}$. Approximately 41 million women and more than 37 million men aged 20 years and over were classified as obese in 2009–2010 (Ogden et al., 2012). More recently, the increasing rate of obesity is slowing down and even starting to plateau (Flegal et al., 2010). The LEO population has also followed this trend (Copay & Charles, 1998). A 2009 study evaluating police retirees suggested that overweight and obesity were more prevalent among law enforcement retirees than the general population (Ramsey, Downing, Franke et al., 2009). A similar study evaluating fire fighters, police officers and other emergency responders found that lack of regular physical activity is one of the top occupational risk factors contributing to the higher prevalence of elevated blood pressure, metabolic syndrome, and CVD among emergency responders (Kales, Tsismenakis, Zhang & Soteriades, 2009). A recent study evaluated the influence of physical activity and perceived stress on metabolic syndrome in male police officers. The study defined metabolic syndrome as, “a constellation of physiological and anthropometric abnormalities including abdominal obesity, insulin resistance, dyslipidemia, and hypertension” (Yoo, Eisenmann, and Franke et al., 2009). The results showed that 23.1% of the sample of police had metabolic syndrome. Regardless of stress level, officers who only engaged in low and moderate physical activity had two-to-three times higher risk of developing the metabolic syndrome than officers who engaged in high levels of physical activity (Yoo, Eisenmann, and Franke et al., 2009). The decrease in physical activity and the increase in obesity can affect LEO’s health, and have harmful outcomes on job performance.

Additional research is warranted to determine what fitness level is needed to enter the police force and what level of fitness is necessary to maintain during the job.

Developing and utilizing valid fitness tests and training recommendations can fill these gaps in the current police fitness protocols. Without proper validation of testing procedures legal challenges can be a major road block for updating testing protocols. If a recruit cannot pass the test to get on the force or an incumbent cannot pass fitness tests; there must be validation to support these punitive or promotional decisions.

The field of tactical strength and conditioning is growing. In an article by Spitler et al. (1987), it was stated that in the past the health and fitness programming with the LEOs has tried to reduce costs of health care, reduce absenteeism, improve health, increase productivity and improve employee attitude and job satisfaction. The majority of health and fitness programs for officers have not been based on empirical data (Spitler, Jones, Hawkins & Dudka, 1987). Without proper exercise prescription for LEOs subjective fitness programs by departments can be ineffective and possibly detrimental to job performance. Spitler and colleagues (1987) provided a major concern among LEO departments by stating: "Lack of knowledge of what constitutes a healthy, effective officer and time or financial constraints often restrict these programs to simple tests of fitness which may or may not reflect the health or job performance capability of the individual officer" (Spitler et al., 1987). Advances in the field of exercise physiology could greatly assist LEOs, fire fighters, and military personnel to identify important physical fitness components for testing and training performance. There are many different jobs that derive from all of these tactical categories, and each need individual attention to know what kind of physical fitness testing and training is needed to be successful. A fire fighter will not need the same training as a patrol officer. There might be certain cross over characteristics, but they are different jobs. Identifying the tasks of

the job, physical fitness programming and testing needs to be completed for each individual tactical job. There has been a separation in the past between strength and conditioning professionals and the LEO profession. Creating a functional relationship between the two groups will help to properly define and development performance standards and fitness programs.

What does it take to be a Law Enforcement Officer?

Law enforcement officers may be required to perform a variety of physical tasks such as apprehending subjects, running up and down stairs, pushing their body over obstacles, dragging objects, and engaging in a foot chase. These tasks are performed while wearing personal safety equipment (e.g., vest, duty belt, side arm, etc.). The weight can vary from 9-kg for a patrol officer to 36kg for special weapons and tactics (SWAT) officers. In addition, these strenuous physical tasks are often performed after sitting in a patrol car for an extended period of time. Given the sporadic, yet potentially physical nature of law enforcement tasks and the importance of performing these essential job functions successfully, it is critical that law enforcement officers achieve and maintain sufficient levels of physical fitness.

There have been a few investigations that have identified predictors of law enforcement physical ability (Rhodes et al., 1992; Stanish et al., 1999; Strating et al., 2010). These investigations have reported a large variety of correlates (i.e., age, body mass index (BMI), anaerobic & aerobic capacity, upper body muscular endurance, lower body power, and agility) to various measures of law enforcement performance (Rhodes et al., 1992; Stanish et al., 1999; Starling et al., 2010). Unfortunately, these studies have not

reported consistent findings regarding characteristics that predict law enforcement physical ability. These discrepancies may be due to the different law enforcement populations evaluated (e.g., Royal Canadian Mounted Police Officers vs. Dutch Police Officers) and differences in the physical ability tasks assessed (i.e., run test vs. physical ability test). The testing methods in the literature have had a lot of variability. Most testing has been modeled after military testing that involves push-ups, sit-ups, and running. Some departments are changing to obstacle course type physical ability testing. In 1991, the Royal Canadian Mounted Police (RCMP) started using the Physical Ability Requirement Evaluation (PARE). The PARE is similar to the Police Officer's Physical Ability Test (POPAT), which was developed for the city police applicants in British Columbia. The PARE and POPAT are meant to simulate the pursuit of a suspect. This is a standardized job-related test, and used for screening and graduating recruits. The PARE had a high failure rate among applicants especially females. The failure rate indicated that subjects were not physically fit enough and/or did not know how to properly prepare for the test (Stanish et al., 1999). For the applicants to pass the test they would have to know the proper fitness attributes to maximize their training (Stanish et al., 1999). This study compared fitness tests to successful time of PARE performance. The subjects in the study were made up of 28 RCMP applicants and 20 university students; ages 19-31 years. A successful time for the PARE test is 4 minutes and 45 seconds or less. The PARE test is an obstacle course composed of long jump (.60-m long), stair climb, hurdles (.45-m high), barrier vault (.9-m high), and controlled fall. The second component is a fight station simulation of a physical struggle. The second component consists of 32-kg pull (via rope pulley system), two controlled falls, and 32-kg push (via

rope pulley system). The fitness characteristics and tests used in this study were: BMI, 1.5 mile run, 1-RM bench press, 1-RM leg press, 32-kg bench press, 40-m sprint, vertical jump, push-ups, long jump, sit-ups, and agility run (Stanish et al., 1999). This study found that for males the continuous 70-lb bench press, agility run, and standing long jump had a moderately high correlation ($r = .64$) with PARE time. The three-variable model explained 79% of the variability in males PARE performance. For the females in this study, they found that agility run time and 1.5 mile run time had a moderately high correlation ($r = .52$ and $r = .66$) with PARE time. The two variable correlation model of 1.5 mile run and agility resulted in 93% successful PARE times for females in the study. The agility test alone had 85% accuracy for predicting PARE success for the females. In this study 19 males were successful and 2 were unsuccessful on their performance on PARE. On the other side of the spectrum 10 females in the study were successful and 17 were unsuccessful. One of the concerns in the results that were mentioned in this study was the small sample size and that some of the subjects were athletes and university students.

A study evaluating 98 police officers (73 men, 25 women) compared successful (POPAT) time to field and laboratory physical fitness tests (Rhodes & Farenholtz, 1992). The POPAT included the following components: obstacle run, agility station, and push/pull apparatus to simulate gaining control of suspects. A successful POPAT time is 4:15 or faster; 16% of the women passed the test and 68% of the men passed the test. The study found that 55% of the variance on the run portion of the test was accounted for by maximal aerobic power and anaerobic capacity (Rhodes & Farenholtz, 1992). The fight component in the POPAT is the same as in the PARE. The study did not find a high

correlation between the fight component and the laboratory strength tests, but there was a moderate correlation ($r = -.34$ to $-.43$) with the fight component to push-up, pull-up, sit-up, and grip strength tests. This study did not look into the strength tests compared to the overall POPAT time.

Strating and coworkers (2010) conducted a study to identify correlates of essential physical competency tasks (PCT) in a sample of 6999 police officers from the Netherlands. The study found that age, gender, and BMI significantly correlated to the PCT (Strating et al., 2010). The PCT has a victim rescue, barrier maneuvers, pulling and pushing of a 200-kg cart, and lifting and carrying 5-kg ball. Age and BMI were positively associated with time to complete the PCT. This study also found that females had significantly slower PCT times than males. Other studies have also found that female officers had slower job-task obstacle course times than male officers (Rhodes and Farenholtz, 1992; Stanish et al., 1999; Strating et al., 2010).

Another required skill that police officers need to have is marksmanship. A police officer in pursuit of a suspect must be quick and accurate with their firearm. Grip strength could be a possible fitness characteristic that would affect marksmanship. To that end, Copay and Charles (2001) conducted a study with 187 male and female police officer recruits to determine if grip strength training would improve marksmanship. The study divided the recruits into a training group who had a small, hand held, spring-loaded, grip strength device and had a training regimen and a control group. Both groups were also going through the same marksmanship training. The study found that the hand held device did not significantly improve grip strength in the training group when compared to the control group. Both groups did improve grip strength by 2-kg at the end

of the academy (Copay & Charles, 2001). Marksmanship scores also improved by the end of the study, but were not different between the two groups.

Related tactical groups

A similar tactical group to police officers is Special Weapons and Tactics (SWAT) operators. SWAT operators resolve distinctive situations that are beyond the normal duties of LEOs. These situations can include regulating riots, hostage rescue, clearing buildings, and situations involving snipers and/or terrorists (Pryor, Colburn, Crill, Hostler & Suyama, 2012). A recent study evaluated eleven male SWAT operators from a suburban department (Pryor et al., 2012). The purpose of the study was to observe physical and physiological stress that SWAT operators endure during a routine tactical entry. The physical tasks that SWAT officers have to complete on the job are: donning and use of tactical gear, recon and securing of the perimeter, dynamic entry of structure, and a man down drill (simulation of removing an injured operator) (Pryor et al., 2012). The operators were also evaluated with physical fitness tests. Body composition, aerobic capacity, strength, power, and flexibility were assessed. The observations from the SWAT tasks revealed that trunk rotation, overhead upper extremity use, isometric upper extremity actions for firearm and shield use, explosive movements in formation, kneeling, and long waiting periods while having to wear equipment (Pryor et al., 2012). The authors of this study came to the conclusion that these job-related tasks required SWAT officers to have a blend of aerobic fitness, extremity strength, core strength, flexibility, and muscular power. The fitness testing results indicated that all the officers performed high in muscular strength except for core strength, and that most were above

average in body composition. SWAT officers could be at risk for lumbar injuries by having inadequate core strength (Pryor et al., 2012).

Firefighters are another tactical group that has been compared to police officers. A study by Rhea and coworkers (2004), recruited twenty professional firefighters to evaluate what physical fitness characteristics were related to job performance. The subjects in the study completed a battery of fitness testing evaluating muscular strength, cardiovascular fitness, muscular endurance, anaerobic endurance, body composition, and an overall fitness variable was created (Rhea et al., 2004). The fitness tests were compared to four separate job performance tasks. The tasks were performed as quickly as possible. The job tasks were timed separately and a comprehensive job performance score created. The job performance tasks were as follows: Hose pull, stair climb, simulated victim drag, and equipment hoist. The results identified that muscular strength, muscular endurance, and anaerobic power/endurance were significantly correlated with firefighter job performance. The overall fitness score was significantly correlated with the job performance total score and three of the four job tasks (Rhea et al., 2004).

Conclusion

Police work can be a truly physically demanding job. Previous studies have found that the job-tasks correlate with attributes like: body mass index (BMI), anaerobic & aerobic capacity, upper body muscular endurance, lower body power, and agility. Incorporating the proper training and testing methods is vital for the functionality of this population. Additional research is needed to further validate these results. Training intervention studies are needed now that these fitness characteristics have been identified.

Finding the proper training methods to optimize all of the characteristics is an important gap that needs to be filled. Using the information from the previous studies can further clarify the physical attributes needed for police work.

Chapter III

Methodology

Experimental Approach to the Problem

This study utilized a cross sectional design to describe the physical fitness levels of university law enforcement officers and to identify physical fitness characteristics that were associated with law enforcement officers' physical abilities. The independent variables were upper and lower body strength, grip strength, low back and hamstring flexibility, core muscular endurance, lower body power, upper body muscular endurance, body composition, and cardiorespiratory endurance. The dependent variable was the time to complete the Officer Physical Ability Test (OPAT).

Subjects

A convenience sample of 16 male university law enforcement officers between the ages of 24 to 51 years were recruited to participate in this study. Table 1 displays the demographic and physical characteristics of the subjects. Approval for the study's procedures was obtained from the University's Institutional Review Board prior to the initiation of the study. All subjects gave written informed consent prior to enrollment in this study. Each subject completed a medical history form. Exclusion criteria for the study were diagnoses of a physical injury that would make it not possible to perform the tasks. Twenty-six subjects began the study, but ten subjects dropped-out due to various reasons including: time constraints, loss of interest, and illness. Subjects participated in four testing sessions separated by at least one day (Table 2). Two practice trials of the OPAT were completed on separate days before the official OPAT trial. The timed

practice testing sessions helped to familiarize officers with the OPAT and established the test-retest reliability of the OPAT.

Table 1. Basic demographic characteristics of 16 university law enforcement officers.

	Mean	±	SD
Age (yr)	33.1	±	8.7
Work experience (yr)	9.8	±	9.1
Height (cm)	178.9	±	7.9
Body mass (kg)	87.2	±	11.2

Table 2. Timeline of assessment procedures.

Session 1	Session 2	Session 3	Session 4
<ul style="list-style-type: none"> • Informed consent • Medical history form • DXA • Anthropometric measures • Sit and reach • Illinois agility test • Bench press • Leg press 	<ul style="list-style-type: none"> • OPAT: Practice trials (2) 	<ul style="list-style-type: none"> • OPAT: Official trial 	<ul style="list-style-type: none"> • Resting blood pressure • Vertical jump • Grip strength • Curl-up • Push-up • GXT

DXA: Dual Energy x-ray absorptiometry *OPAT: Officer Physical Ability Test; GXT: Graded exercise test. Each testing session was conducted on a separate day

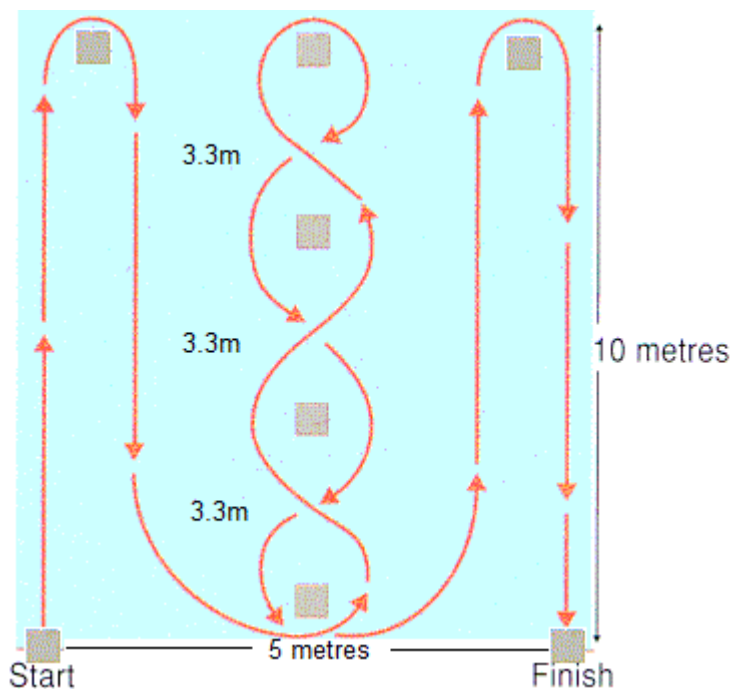
Agility Test

The Illinois Agility Test was used to assess agility. The test was timed using a Sportline Sport Timer (Yonkers, NY). The time sensitivity recorded was to the tenth of a second. The test-retest reliability of the agility test in this sample was $r = 0.97$.

Subjects completed a standardized dynamic warm-up, which was led by an investigator.

The subject started the test in the prone position behind the start line. Immediately following the starting signal, the subject jumped to his feet and navigated through the course shown in Figure 1. The subject performed two trials, with 3 minutes of recovery between each trial. The fastest trial completed was used for data analyses.

Figure 1. Schematic of the Illinois Agility Test.



Strength Assessments

Muscular strength was assessed with a 2-5 repetition maximum (2-5 RM) test on the leg press and free-weight flat bench press. A leg press machine was used to assess lower body strength (6000-A leg press, Nebula Fitness Equipment, Columbus OH). A standard protocol was used to evaluate bench press and leg press strength (Baechle, Earle & Wathen, 2008; Heyward, 2010). Briefly, subjects performed a warm-up set composed of five to ten repetitions at 40-60% of the subjects' estimated 5-RM. After one minute of recovery, the subject performed five repetitions of 60-80% of the estimated 5-RM. Three to five minutes of rest was provided for each set thereafter and the weight was increased

2.3-4.5-kg per set for bench press and 6.8-9.0-kg per set for leg press until the subject could only complete between two and five repetitions. The maximal load lifted was recorded. A prediction formula was used to estimate 1RM strength. The prediction equation used for bench press was: $1RM = \text{load} / 1.0278 - 0.0278 \cdot \text{repetitions}$ (Brzycki et al., 1993). The prediction equation used for leg press was: $1RM = (0.33 \cdot \text{repetitions}) \cdot \text{load} + \text{load}$ (Epley et al., 1985).

Push-Up Test

A maximal push-up test was used to assess upper body muscular endurance. The testing procedures described by the American College of Sports Medicine were used (ACSM, 2010). Specifically, the subject maintained a prone position on a mat with the legs together and hands facing forward under the shoulders. The starting position was pushing off the mat with arms fully extended and using the toes as the pivot point. The subject was instructed to keep his body in a straight line with the head up. The subjects lowered themselves to the down position and touched their chest to a 7.6-cm tall sponge. The sponge was used because it standardizes the downward position for all subjects and is used in the police academy. The subject was instructed to not touch their stomach or thighs to the mat when in the down position. The subject completed as many consecutive repetitions as possible. There was no rest and no time limit for this test. The test was terminated when the subject could not keep proper form or reached failure. The total number of consecutive push-ups was recorded.

Curl-Up Test

The curl-up test was used to assess core muscular endurance using a set of standardized procedures (ACSM, 2010). The subject was instructed to lie supine on a mat with knees bent at 90°, legs hip-width apart, and arms fully extended at the sides with the middle finger of both hands touching a piece of tape. The first piece of tape was used to mark zero and a second piece of tape was placed 10-cm beyond the zero marker. A metronome was set at 50 b•min⁻¹ (i.e., rate of 25 repetitions per minute). The subject was instructed to curl up until his middle finger touched the second piece of tape in time with the metronome. Furthermore, the subjects were required to keep the palms of his hands and the heels of his feet in contact with the mat. Lastly, the subject was instructed to keep the shoulders and head in contact with the mat and to touch the middle finger to the zero marker at the end of each repetition. The total number of successfully completed repetitions was recorded.

Vertical Jump Test

Vertical jump was used as an assessment of lower body muscular power. The subjects performed two practice trials and three official trials. The testing protocol used was composed of a set of standardized procedures (Baechle & Earle, 2000). A vertical jump device (Vertec, Sports Imports, Columbus, OH) was used to measure vertical jump height. First, standing reach was measured with the device. The subject touched the highest vein on the device while standing with both feet flat on the ground and reaching upward with their dominant arm, being sure to keep the arm, wrist, and hand straight. Second, the subject was instructed to jump straight up as high as possible with the

dominant arm and tap the highest vein on the device. No preparatory steps or shuffling were allowed. The test took place on a wood gymnasium floor. Vertical jump height was calculated as the difference between the standing reach and the highest jump reach score.

Grip Strength Test

Grip strength was measured using a handgrip dynamometer (model 78010, Lafayette Instrument Company, Lafayette, ID). The dynamometer was adjusted to a comfortable grip position for each subject. The subject was instructed to stand erect with the shoulder adducted and neutrally rotated, elbow at 90°, forearm in neutral position, and wrist in slight extension (Heyward, 2010). The subject was instructed to maximally contract finger flexor muscles with no extraneous body movements. Three trials were completed by both hands. One minute of rest was provided between trials and the best score for each hand was used in the analysis.

Sit-and-reach

The sit-and-reach test was used to assess lower back and hamstring flexibility. The Acuflex I was used to measure sit-and-reach (Novel Products Inc., Rockton, IL). The device has a sensitivity of 1-cm. The standardized testing procedures have been described elsewhere (ACSM, 2010). The footplate of the sit-and-reach box was set at 23-cm. The subject sat on the floor with his knees extended and soles of feet (without shoes) against the edge of the box. The subject's feet were placed 15.2-cm apart. The subject was instructed to keep knees extended, arms evenly stretched, and hands overlapped with the palms down reaching as far forward as possible along the top of the box. The subject

held the farthest reach for two seconds. The farthest measurement of two trials was used for data analysis.

Maximal Oxygen Consumption

An aerobic capacity test was performed to measure peak oxygen consumption ($\text{VO}_{2\text{peak}}$). A maximal graded exercise test (GXT) was performed on a treadmill with a 12-lead electrocardiogram (ECG). Prior to the GXT, each subject ran on the treadmill to select a speed that felt “comfortable”. This speed was used during the GXT. The GXT testing protocol began with the subject walking for 3 minutes at $80.4 \text{ m}\cdot\text{min}^{-1}$. Then, the treadmill speed was increased to the subject’s self-selected running speed and the grade was increased every two minutes until volitional exhaustion was reached. A metabolic cart (TrueOne 2400 Metabolic Measurement System, Parvo Medics, Sandy, UT) was used to measure oxygen consumption in a breath-by-breath fashion, and the resulting measures were then averaged over one minute time intervals. Gas and flow rate calibrations were conducted prior to testing. Specifically, O_2 and CO_2 analyzers were calibrated using gases of known concentrations (O_2 : 16%; CO_2 : 4%). Flow rate was calibrated with a 3-L syringe (Hans Rudolph, Inc., series 5530, Kansas, MO) at rates ranging from $50\text{-}500 \text{ L}\cdot\text{min}^{-1}$. Rating of Perceived Exertion Scale (RPE) was assessed during each stage of the GXT protocol using a 15 point scale (Borg, 1973). The subjects’ heart rate was continuously monitored during the protocol using an ECG. The test was terminated if the subjects presented adverse symptoms, could not continue or requested to stop.

Body Composition

Body composition was assessed via dual energy x-ray absorptiometry (DXA). Specifically, the DXA measured fat mass (FM). The total body DXA scan was performed using a Lunar DPX-IQ (Lunar Inc., Madison, WI) bone densitometer. The subjects were instructed to remove all objects such as jewelry or eyeglasses and wore lightweight shorts and a t-shirt containing no metal. All scans were analyzed by a single trained investigator using the Lunar software version 10.0.

Officer Physical Ability Test (OPAT)

The OPAT was designed to simulate a foot chase pursuit of a suspect. Identification of the OPAT tasks were based on the recommendation of an expert informant (i.e., University's Police Chief) and based on tasks commonly reported in law enforcement literature (Arvey, Landon, Nutting & Maxwell, 1992). The OPAT was performed twice for familiarization purposes on a separate day from the official trial to minimize any effect of residual fatigue (Table 2) and to establish the reliability of this test. These trials were performed in full tactical gear. The test-retest reliability of the OPAT was $r = 0.95$ (Cronbach's Alpha) and had a standard error was .564 s from trial 1 to trial 2. To establish the validity of the OPAT, a brief questionnaire was given to the officers. Specifically, the questionnaire asked the officers to rank the relevancy of each OPAT task and rank the overall relevancy of the OPAT. The ranking of relevancy consisted of the following scoring: 1 = poor relevance; 2 = fair relevance; 3 = good relevance; 4 = very good relevance; and 5= excellent relevance). The descriptive statistics

of the relevancy survey are presented in Table 3. The median (minimum – maximum) response of the overall relevancy of the OPAT was 5 (3–5).

Table 3. Descriptive statistics for the officer physical ability test relevancy survey (n = 12).

	Median	(min-max)
Overall relevancy	5	3-5
Ascending/descending stairs	5	2-5
200 m run	5	2-5
Over barriers	5	3-5
Under barriers	4	2-5
Rescue	4	2-5
Apprehending suspect	5	3-5

During the official OPAT the officers wore full tactical gear, including an armored vest, duty belt with a mock sidearm, and radio. In addition, to evaluate the cardiovascular demand of the OPAT, officers wore a heart rate monitor (T31, Polar, Finland) under their tactical gear. A second device (ActiTrainer, Pensacola, FL) was worn in a neoprene sleeve around officers' upper arm to record heart rate. The device's internal clock was synchronized to a personal watch and each officer's OPAT start and finish times were recorded to identify the appropriate heart rate data to be used for analysis. The device was later downloaded to a personal computer using the manufacturer's software (ActiLife, Version 5) and the average heart rate during the OPAT was calculated. Heart rate was expressed as an absolute value ($b \cdot \text{min}^{-1}$) and as a percentage of the officers' maximum heart rate based on the peak heart rate identified during the graded exercise test. A stopwatch (Sportline Sport Timer, Yonkers, NY) was used to time the overall OPAT and to quantify the time required to complete each OPAT task. These times were recorded to the nearest tenth of a second. The individual tasks were performed consecutively,

without recovery. A description of the OPAT tasks follows. Prior to initiating the OPAT, the officer remained seated in a chair (simulating a patrol car) for approximately 2 minutes. When instructed, the officer stood up and proceeded 2.7-m to a set of 10 concrete stairs (Stair ascent #1). Following the ascent of these stairs, the officer ran 38.4-m, opened a door and entered a building (Building entry). The officer then proceeded to a second staircase. The officer ascended and descended a flight of 14 stairs (Stair ascent/descent). At the bottom of the stairs the officer turned right and ran 9.8-m and climbed or jumped over a 0.91-m barrier. The officer then ran 159-m on a rubberized track (Run). Next, the officer turned right and proceeded to a set of barriers on artificial field turf (Barrier maneuver). The officer proceeded 7.3-m and maneuvered over a 0.91-m barrier. Next, the officer ran 4.3-m and jumped over a 1.5-m long obstacle. Then, the officer ran 5.2-m and crawled under a 0.91-m barrier. The subject ran 5.8-m and crawled under another 0.91-m barrier. Next, the officer drug a 48.5 kg mannequin a distance of 13.7-m. The mannequin was then turned over in the prone position and the officer was required to pull the mannequin's wrists together simulating a normal law enforcement cuffing protocol (Rescue/arrest). Finally, the officer ran 9.1-m to the finish line (Sprint). A five second time penalty was added to the total OPAT time if the officer knocked over a barrier. Two officers incurred the five second time penalty.

Statistical Analysis

To assess the relationship of overall physical fitness versus occupational physical ability, a "blended" fitness score was created to represent overall physical fitness. Specifically, standardized z-scores were calculated from the following variables: agility time, 1RM bench and leg press, push-up, curl-up, vertical jump, sit-and-reach, VO_{2peak} ,

and percent body fat. All variables were scored such that higher values represented superior performance and lower values represented inferior performance. Therefore, several variables were reverse scored given that lower scores represented superior performance (e.g., agility time and percent body fat). The standardized scores were then averaged across all physical fitness variables to create a blended fitness score for each subject. Basic statistics (mean & standard deviation) were used to describe the subjects' health, physical fitness, and performance outcomes. The normality of each variables' distribution was evaluated with Fisher's skewness coefficient (Coefficient = skewness / standard error of skewness). A distribution with a skewness coefficient outside of the absolute value of 1.96 was considered to be significantly skewed. The data were distributed normally, except for the curl-up test. The curl-up test was positively skewed (Fisher's skewness coefficient = 2.23) due to a single outlier. However, we evaluated the data with and without this outlier and determined that the presence or absence of the outlier did not change the outcome, thus the outlier remained in the analysis. Pearson product moment correlations were used to identify significant associations between physical fitness measures and time to complete the OPAT. The level of significance was set at $P < 0.05$ for all statistical analyses.

Chapter IV

Results

Tables 4 and 5 display the descriptive statistics for the OPAT times and officers' physical fitness outcome measures, respectively. The mean absolute and relative heart rates during the OPAT were $162.7 \pm 14.8 \text{ b}\cdot\text{min}^{-1}$ and $88.6 \pm 4.7\%$, respectively. The correlations between OPAT performance and physical fitness characteristics are presented in Table 6. Blended fitness was significantly correlated with the total OPAT time and with 5 of 7 OPAT tasks. The agility test (related to 6 of 7 tasks), curl-up (related to 4 of 7 tasks), $\text{VO}_{2\text{peak}}$ (related to 3 of 7 tasks), push-up (related to 3 of 7 tasks), vertical jump height (related to 3 of 7 tasks), and bench press (related to 2 of 7 tasks) tests were correlated with the overall OPAT time and with at least 2 out of the 7 OPAT tasks.

Table 4. Officers physical ability test (OPAT) task times in 16 subjects.

Task	Mean	±	SD	% of Overall time
Overall time (s)	107.2	±	17.8	
Stair ascent #1 (s)	2.9	±	0.5	2.7
Building entry (s)	11.4	±	1.4	10.6
Stair ascent/descent (s)	7.9	±	1.5	7.4
159 m run (s)	42.8	±	7.8	39.9
Barrier maneuver (s)	16.7	±	3.4	15.6
Rescue/arrest (s)	22.3	±	7.2	20.8
Sprint (s)	2.8	±	0.8	2.6

Regarding specific tasks, stair ascent #1 was significantly positively correlated to the agility test, and significantly negatively correlated with blended fitness and the curl-up test. The building entry task was significantly positively correlated to the Illinois agility test and percent fat, and significantly inversely correlated with blended fitness, $\text{VO}_{2\text{peak}}$,

push-up, curl-up, vertical jump, and relative bench press tests. The stair ascent/descent tasks was significantly positively correlated with the Illinois agility test and significantly inversely correlated with blended fitness, VO_{2peak} , push-up, curl-up, and vertical jump tests. The 159-m run task was significantly positively correlated to the agility test and percent fat, and significantly inversely correlated with blended fitness, VO_{2peak} , push-up, curl-up, vertical jump, and bench press tests. The barrier maneuver and rescue/arrest tasks were significantly positively correlated to the agility test. The physical fitness characteristics sit-in-reach, right and left hand grip strength were not significantly correlated to any portion of the OPAT.

Table 7 displays the correlation matrix between demographic characteristics and the OPAT task times. The overall OPAT was significantly positively correlated with age, work experience, waist circumference, and abdominal circumference. Building entry task was significantly positively correlated with age, work experience, body mass, waist circumference, and abdominal circumference. Stair ascent/decent was significantly positively correlated with age, work experience, waist circumference, and abdominal circumference. The 159-m run task was significantly positively correlated with age, work experience, waist circumference, and abdominal circumference. Rescue/arrest task was significantly positively correlated with age. Hip circumference and standing height were not significantly correlated to the OPAT tasks.

Table 5. Physical fitness characteristics of university law enforcement officers.

	Mean	±	SD
<u>Anthropometrics</u>			
Body fat (%; n=16)	22.7	±	4.2
Waist circumference (cm; n=16)	90.6	±	8.8
Abdominal circumference (cm; n=16)	93.5	±	9.8
Hip circumference (cm; n=16)	103.3	±	6.2
<u>Muscular endurance</u>			
Push-up (repetitions; n=14)	34.8	±	12.6
Curl-up (repetitions; n=14)	55.6	±	45.9
<u>Muscular strength</u>			
Bench press (estimated 1RM; kg; n=15)	92.9	±	19.7
Leg press (estimated 1RM; kg; n=15)	645.6	±	116.2
Relative bench press (kg·BM ⁻¹ ; n=15)	1.1	±	0.3
Relative leg press (kg·BM ⁻¹ ; n=16)	7.6	±	1.6
Hand grip -left hand (kg; n=15)	52.5	±	5.9
Hand grip -right hand (kg; n=15)	55.9	±	6.4
<u>Muscular power</u>			
Vertical jump height (cm; n=15)	51.4	±	10.2
<u>Agility</u>			
Illinois agility test (s; n=16)	18.2	±	1.6
<u>Aerobic endurance</u>			
VO _{2peak} (ml·kg ⁻¹ ·min ⁻¹ ; n=14)	42.7	±	5.9
<u>Flexibility</u>			
Sit-and-reach (cm; n=16)	32.1	±	9.8

Table 6. Matrix representing the correlations between officer physical ability test (OPAT) times and physical fitness characteristics.

OPAT task	Blended fitness	Illinois agility	VO _{2peak}	Push-up	Curl-up	Vert. jump	Bench press	Leg press	% fat	Sit & reach	Rt. hand grip	Lt. hand grip
Total time	-0.79 [†]	0.75 [†]	-0.65*	-0.73 [†]	-0.69 [†]	-0.64*	-0.56*	-0.26	0.52*	0.05	-0.30	-0.13
Stair ascent #1	-0.64*	0.64 [†]	0.18	-0.43	-0.60*	-0.46	-0.40	-0.18	0.12	-0.02	-0.36	-0.17
Building entry	-0.84 [†]	0.67 [†]	-0.61*	-0.76 [†]	-0.65*	-0.54*	-0.62*	-0.33	0.54*	0.21	-0.28	-0.19
Stair ascent/descent	-0.79 [†]	0.74 [†]	-0.66 [†]	-0.63*	-0.74 [†]	-0.68 [†]	-0.47	-0.19	0.48	0.05	-0.20	-0.04
159-m run	-0.83 [†]	0.71 [†]	-0.66*	-0.75 [†]	-0.74 [†]	-0.65 [†]	-0.63*	-0.31	0.59*	0.14	-0.39	-0.3
Barrier maneuvers	-0.35	0.52*	-0.38	-0.30	-0.49	-0.45	-0.06	0.19	0.14	-0.16	-0.31	-0.09
Rescue/arrest	-0.58*	0.52*	-0.53	-0.51	-0.34	-0.37	-0.50	-0.21	0.36	0.05	-0.07	-0.08
Sprint	-0.26	0.44	-0.29	-0.09	-0.29	-0.33	-0.27	-0.28	0.34	-0.36	-0.04	-0.11

Vert: vertical; Rt: right; Lt: left.*p < 0.05; †p < 0.

Table 7. Matrix representing the correlations between officer physical ability test (OPAT) times versus demographic and anthropometric variables in 16 officers.

OPAT task	Age	Work experience	Height	Body mass	Waist circ.	Abdominal circ.	Hip circ.
Overall time	0.67*	0.67 [†]	-0.10	0.22	0.54*	0.51*	0.28
Stair ascent #1	0.42	0.45	-0.08	0.20	0.46	0.40	0.09
Building entry	0.58*	0.63 [†]	0.34	0.62*	0.68*	0.71 [†]	0.48
Stair ascent/descent	0.62*	0.65 [†]	0.04	0.35	0.54*	0.52*	0.21
159 m run	0.76 [†]	0.76 [†]	0.04	0.33	0.52*	0.54*	0.23
Barrier maneuvers	0.21	0.21	-0.21	0.07	0.37	0.25	0.09
Rescue/arrest	0.52*	0.49	-0.33	-0.08	0.34	0.30	0.18
Sprint	0.01	-0.07	-0.44	-0.02	0.17	0.26	0.33

Waist:Waist Circumference (cm); Abdominal : Abdominal Circumference; Hip: Hip circumference; * p < 0.05; [†]p < 0.01

Chapter V

Discussion

The purpose of this study was to identify physical fitness and demographic characteristics that are associated with the occupational physical ability of university law enforcement officers. The physical fitness characteristics that significantly correlated with the OPAT time were: blended fitness, agility, upper body muscular endurance, core endurance, lower body power, upper body strength, aerobic endurance, and relative body fat.

There is existing literature evaluating relationships between physical fitness and occupational physical ability. For example, Stanish and colleagues (1999) conducted a study to identify physical fitness correlates of a Physical Ability Requirement Evaluation (PARE) in 48 Royal Canadian Mounted Police. Similar to the present study, Stanish et al. (1998) reported that collectively, upper body muscular endurance, agility, and lower body power were explained a significant amount of the variance in PARE performance ($R^2 = 0.79$). Furthermore, Stanish et al. (1999) reported that 43% of the variance in PARE performance was accounted for by agility alone for female officers (Stanish et al., 1999). Similarly, the present study found that 56% of the variance in OPAT time was accounted for by the Illinois agility test. Even though the present study and Stanish et al. (1999) study used different tests for the agility (present study: Illinois agility test; Stanish et al., (1999): Barrow zigzag agility run), upper body muscle endurance (present study: push-ups; Stanish et al. (1999): 31.8-kg bench press repetitions to failure), and lower body power output (present study: vertical jump; Stanish et al. (1999): standing long jump) the magnitude of the correlations between these fitness outcome and occupational

performance were similar. These congruent findings indicate that agility, upper body endurance, and lower body power are important aspects of law enforcement physical ability. Thus, fitness programs for law enforcement officers should incorporate training modalities to improve these outcomes, and physical fitness tests should include assessments of these outcomes.

Strating and coworkers (2010) also conducted a study to identify correlates of essential physical competency tasks (PCT) in a sample of 6,999 police officers from the Netherlands. The study found that age, gender, and BMI significantly correlated to the PCT (Strating et al., 2010). Thus, both studies found that age and anthropometric measures were correlated to occupational physical ability. Specifically, older age and unfavorable anthropometric measures were related to a decrease in work efficiency. Unlike the Strating et al. (2010) study, the present study did not evaluate the effect of gender on occupational physical ability because only male officers volunteered for the study. These findings are important for police departments to consider, as comprehensive exercise and wellness programs should be implemented to enhance the body composition of officers.

Rhodes and Farenholtz (1992) conducted a similar investigation using a Police Officer's Physical Ability Test (POPAT) which included the following components: an obstacle run, agility station, and push/pull apparatus to simulate gaining control of a suspect. This study found that 55% of the variance on the run component of the POPAT was accounted for by maximal aerobic power and anaerobic capacity. Likewise, the present study also found that aerobic capacity was correlated to occupational physical ability. In addition, Rhodes and Farenholtz (1992) found that there was a moderate

correlation ($r = 0.34-0.43$) between the fight component of the POPAT versus push-up, pull-up, sit-up, and grip strength tests. These findings seem logical given that hand-to-hand combat and grappling require upper body strength and endurance. Unfortunately, the present study did not assess combat performance.

Spitler and colleagues (1987) conducted a study evaluating the physical fitness characteristics of 9 male and 3 female metropolitan police officers in North Carolina. When comparing similar physical fitness tests, the officers in the present study performed similar or better than officers in the Spitler et al. (1987) investigation. That is, the officers in the present study had superior mean scores for vertical jump height (51.4 vs. 42.4-cm), 1RM bench press (92.9 vs. 64.3-kg), push-ups (34.8 vs. 27.2 repetitions), hand-grip strength (55.9 vs. 24.1-kg), and sit-and-reach distance (9.1 vs. 6.1-cm past feet). The superior performance in absolute measures of muscular endurance, strength, and power in the present study may be due to the fact that Spitler et al. (1987) included 3 female officers in the sample. Research indicates that males have greater absolute upper body strength than females (Bishop et al., 1987). Further evidence indicating that gender may be responsible for the muscular fitness differences between these studies is that other physiological outcomes reported by Spitler et al. (1987) were just among male officers and thus more comparable to the present study (aerobic capacity: present study = $42.7 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, Spitler et al. (1987) = $42.1 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$; relative body fat: present study = 22.7%, Spitler et al. (1987) = 24.4%). Rhodes and Farenholtz (1992), Stanish et al. (2010) and Strating et al. (1999) evaluated the effect of gender on completion rates of their physical ability tests. The findings indicated that women had lower success rates compared to men on these assessments (PARE, POPAT& PCT). Unfortunately, the

present study did not evaluate the effect of gender. However, it is logical to suggest that police departments should implement physical training programs to enhance the physical fitness of female law enforcement officers.

To the best of our knowledge, this was the first study to evaluate the relationship of overall or blended fitness with law enforcement physical ability. However, the development and analysis of an overall fitness variable is not entirely novel among tactical populations. For instance, Rhea and colleagues (2004) created an overall fitness variable and found that it was correlated to firefighter physical ability. Although some of the firefighter tasks were different from those used by the law enforcement officers in the present study (i.e., hose pull & equipment hoist), others were similar (i.e., victim drag & stair climb; Rhea et al., 2004). Regardless, the firefighter tasks utilized by Rhea et al. (2004) appear to tax all three energy systems (i.e., phosphagen, glycolytic, oxidative), thus it is not surprising that they also found relationships between overall fitness and occupational physical ability. Given that the overall fitness score accounted for physical fitness characteristics that span the fitness spectrum; this indicates that tactical strength and conditioning professionals need to develop appropriate and effective comprehensive training programs that address all of these fitness characteristics for law enforcement officers.

The current method of physical fitness testing for law enforcement recruits in the state of Kentucky (location of the present study) is the Peace Officers Physical Standards (POPS). The POPS testing is used as a requirement for recruits to graduate from the police academy. This test is comprised of bench press (% of body weight for maximal repetitions), sit-up test (repetitions per 1 min), 300-m run, push-up test (repetitions in 2

min), and 1.5 mile run. The bench press test is a percentage of body weight for both females and males. The present study found upper body strength, core endurance, upper body muscular endurance, and aerobic capabilities significantly correlated with occupational physical ability. Therefore, the present study supports the use of current POPS assessments, as they were correlated to our measure of occupational physical ability. Furthermore, we found that agility and lower body power were also correlated to the OPAT, and these fitness characteristics are not included in POPS testing. Adding these assessments to the POPS testing may provide a more comprehensive assessment of officers' physical fitness as they relate to occupational physical ability.

Limitations

There are several limitations to this study. First, this study utilized a relatively small sample size. However, even with the small sample size, significant correlations were identified, indicating adequate statistical power. Additionally, there were no female participants in this study. Thus, the findings cannot be generalized to female law enforcement officers. Additional research is warranted among female officers given that other studies have found that women tend to perform worse on occupational physical ability tests. Finally, the OPAT was not thoroughly validated according to proposed employment standards (Payne & Harvey, 2010). However, the purpose of the OPAT was simply to provide an estimate of actual physical tasks performed on the job, not to be used for punitive or promotional purposes. The tasks included in this test were identified based on the input of an expert informant (i.e., Police Chief) and its level of validity was, in part, supported by the acceptable relevancy survey responses of the officers who participated in the OPAT.

Practical applications

The present study found that blended fitness, agility, upper body muscular endurance, core endurance, lower body power, upper body strength, and aerobic endurance were associated with law enforcement physical ability. These findings may help to guide future law enforcement recruits and incumbent law enforcement officers with regard to focusing on the identified fitness characteristics to improve occupational physical ability. Furthermore, these findings will assist tactical strength and conditioning professionals to identify which fitness components should be targeted in the exercise program. Future research should evaluate various periodization strategies (e.g., linear, nonlinear, block training) to identify the most effective training method to improve multiple competing fitness outcomes to enhance law enforcement physical ability. Developing a training program for law enforcement officers is challenging given that there are no designated seasons (i.e., off-season, preseason, etc.). Furthermore, tactical strength and conditioning professionals need to determine the most effective approach at training officers on- and off-duty to maximize physiological adaptations while minimizing the effect of residual fatigue.

The present study indicated that officers' age and work experience were inversely related to police officer physical ability and thus less efficient in performing physical occupational tasks. Therefore, it is critical that officers maintain adequate physical fitness levels as they age. These findings highlight the importance for police departments to implement a physical fitness program to help officers maintain physical fitness as they age. The mean relative heart rate during the OPAT was 88.3% of maximum; which indicates that officers have to be physically fit to work effectively at high intensities.

Furthermore, this study found that relative body fat and waist and abdominal circumferences were associated with occupational physical ability. These findings indicate the importance of utilizing weight management strategies for officers, including nutritional and exercise programs.

Conclusion

In summary, law enforcement officers have a demanding and potentially dangerous job. Maintaining adequate levels of fitness based on the characteristics identified in this study is critical to performing the job effectively. Tactical strength and conditioning professionals must design exercise programs for academic law enforcement officers that improves multiple components of physical fitness and focuses on weight management.

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