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Battery Fitness Testing in Law Enforcement: A Critical Review of the Literature

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ABSTRACT

International Journal of Exercise Science 14(4): 613-632, 2021. Police trainees undergoing training to prepare them for the occupational demands of policing are often subjected to fitness testing. The aim of this review was to critically appraise research studies employing police fitness tests. Method: A comprehensive search of four databases (PubMed, EMBASE, and Ebscohost [CINAHL and SportDiscus]) was conducted by two authors independently. After duplicate articles were removed, articles that did not meet the pre-determined inclusion criteria and met the exclusion criteria were removed. The remaining studies were critically appraised by two authors independently using a Downs and Black Checklist. Cohen's Kappa coefficient was used to measure the level of agreement between appraisers and calculated by a third author. The grading system proposed by Kennelly was used to grade the methodological quality of the studies. Results: From an initial 7384 identified studies, including four from additional sources, 11 studies met the criteria for review. The mean critical appraisal score for the articles was 74.36 (± 1.48%) being considered 'good' quality and a 'substantial' level of agreement was found between the two appraisers (k = 0.75). The most common measures assessed were muscle endurance (push-ups and sit-ups) and aerobic capacity (running), with the least common measure being agility. Assessments of push-ups and the 2.4-km (1.5-mile) run had the strongest correlations to law enforcement academy graduation across the studies. Grip strength may predict occupational performance (marksmanship) as well as longevity. Conclusion: The push-up and 2.4 km (1.5-mile) run fitness tests were the most popular fitness assessments and had the strongest positive correlation to law enforcement academy graduation.

KEY WORDS: Police; aerobic capacity; assessment; recruits; tactical

INTRODUCTION

Tactical personnel, such as police officers, offer a sense of security in an endangered world. Accordingly, police officers have physically and mentally demanding requirements to fulfil as part of their occupation (10). Examples of these challenging tasks include grappling with suspects or running towards an emergency situation (10). Without the service of incumbent officers, the protection of society and maintenance of law and order may become compromised (38). For this reason, the preservation and longevity of police officers is vital for society (5). The tasks that police officers perform when protecting society from danger and eliminating threats in real time has been shown to require adequate physical capacity to be performed effectively and safely (10). These tasks exemplify the need for police officer to attain and maintain a certain level of health and occupational physical fitness (2).

Recent research supports the notion that police officers' fitness can improve occupational performance (14, 28). For example, grip strength was positively correlated with a police officer's firearm marksmanship with increased grip strength found to be correlated with increased accuracy (28). Agility tests have been shown to be related to policing tasks such as ascending and descending stairs, a situation that may present itself during search and rescue tasks or chasing offenders through an urban area (2). Likewise, lower body power may be required when jumping over barriers and when chasing suspects (19). The importance of fitness in this occupation is further highlighted whereby, upon recognizing that more physically fit law enforcement officers have an increased ability to handle physical, emotional, and mental stresses related to their occupation, the Federal Bureau of Investigation initiated a fitness program for its agents (14). This physical training program mainly consisted of aerobic based training in the form of running, however, certain challenges included obstacle courses, combining elements of upper and lower body strength (14). Due to the evident need for fitness in police officers, it is only logical that potential recruits partake in a thorough, yet efficient, physical screening process for the safety of the officers as well as the civilian population.

Research shows that decreased muscular power, strength, metabolic fitness, and muscular endurance are components of physical fitness that may be associated with injury amongst police officers (27-30). A study conducted by Orr et al. (29) examined the relationship that push-ups (muscle endurance), vertical jump (muscle power), and grip strength (muscle strength) had on injury rates amongst police recruits. Recruits with the lowest push-up scores were more than seven times as likely to develop an injury in comparison to recruits who scored highest in the push-up category (29). Vertical jump and grip strength scores also had significant correlations to injury risk (29). In a separate study a clinically significant relationship was found between low vertical jump scores and the occurrence of injury or illness amongst police recruits (27). Furthermore, Nabeel et al. (24) found that police officers that were more physically fit had lower instances of musculoskeletal injuries. A possible explanation as to the decreased occurrence of injury amongst physically fit police officers in contrast to their less fit colleagues may be due to the reduced likelihood of reaching aerobic, muscular, and neuromuscular fatigue during training or when performing occupational tasks (27). As physical fitness provides further potential benefits beyond injury reduction for officers, it may be even more paramount.

Research states that aerobic/cardiovascular fitness has several health benefits (16). This is important to consider as police officers may spend a great deal of time engaged in sedentary tasks (4). Birzer and Craig (3) estimated that police officers spend an average of about five hours sitting while on the job. Nonetheless, the need to perform strenuous physical tasks is an expected challenge for incumbents to overcome if an adverse situation presents itself (8). For example, an analysis by Decker et al. (12) on Australian police found that officers must meet the challenge of adapting to very high physiological demands in times of crisis. This study presented cases of officers attending to occupational tasks with very high heart rate measures, at times well above their age-predicted maximum heart rate. As an example, in one day a 40-year-old male officer exceeded his age-predicted maximum heart rate three separate times while attending to occupational tasks (12). As police officers have a relatively high risk of suffering cardiovascular disease, (which can potentially be fatal) (34), instances that force an officer to go from a sedentary state to a physiologically demanding state become much more concerning (33). It should also be noted that while an officer may appear to be performing a sedentary act (i.e., driving), the physiological response due to the sympathetic response and situational stress may elevate heart rate under these conditions. Thus, the need for cardiovascular fitness is quite evident in this population.

Until a few decades ago, many police agencies selected police officers in the United States based primarily off their height and body mass, as it was believed that taller and heavier officers had higher levels of strength and endurance (3). Although this practice has generally been abolished, it does highlight the perception that physical capacity of trainee police officers has been considered for a substantial amount of time. More recently, attention has shifted from physical characteristics of new trainees to the physical capabilities of these same trainees using fitness testing. The importance of physical fitness testing extends to the point that liability for a police officer's lack of strength and ability may be placed on the department which hired the officer (4). Therefore, the aim of this review was to critically appraise the research studies which report on the employment of fitness tests in the police force.

METHODS

Protocol

To identify relevant literature to inform this review, a systematic search of key databases (PubMed, Embase, CINAHL, and SPORTDiscus) was conducted. Relevant search terms were derived from known literature and subject matter experts conducting research in this field. These terms were intentionally kept broad to reduce the risk of selection bias. Table 1 outlines the databases used, filters applied, and database-specific search terms. Searches were performed by two authors independently with all identified articles extracted into EndNote. Once identified articles were extracted, all duplicates were removed with the remaining articles independently screened by two authors by the study's title and abstract for relevance. A further four articles were provided by an external source that were used in this review. The remaining articles were then subjected to dedicated inclusion and exclusion criteria which were developed prior to screening (Table 2). A 15-year limitation was applied in the search process as part of the

inclusion criteria to ensure the studies used were more recent and therefore more relevant in the current law enforcement climate (36). Articles which reported on only one measure of fitness were excluded as the assessments conducted as part of a battery of tests were of interest to this review. The PRISMA diagram (Figure 1) outlines the search process. Any discrepancies in the process by the two reviewers were adjudicated by a third author so that consensus was reached.

Table 1. Databases and Relevant Search Terms

Database	Search Terms
PubMed	Police OR Patrol Officers OR Cadet OR Recruit AND Exercise Test OR "Physical Fitness Assessment" OR Fitness Test* OR "Entry Test" Filters: Humans; English; Field: Title/Abstract
Embase	Police OR sheriff OR cadet OR "incumbent officers" AND fitness test* OR physical test* OR "evaluation" OR strength OR cardiorespiratory OR endurance OR aerobic OR training Filters: English; Year: 1997-2018; Humans
CINAHL	Police OR Patrol Officers OR Cadet OR Recruit AND Exercise Test OR "Physical Fitness Assessment" OR Fitness Test* OR "Entry Test" AND OR aerobic OR strength OR exam* OR screen* OR test* OR orientation Filters: English; Year: 1997-2018; Humans; Peer Reviewed
SportDiscus	"Police" OR patrol officer OR recruit OR cadets AND "Exercise Test" OR "Physical fitness assessment" OR "Fitness test" OR "physical performance test" OR "Entry Test" Filters: Published Date: 1997-2018; English; Peer Reviewed, Academic Journals

Statistical Analysis

To determine the methodological quality of the research, the Downs and Black (13) critical appraisal tool was used. This tool employs a checklist of 27 questions with 25 of these questions scoring either a '0' or a '1'. Question five, identifying confounders, is marked out of 2 with '1' point awarded for a 'partial' and '2' points for a 'yes' for listing confounders. Question 27, which discusses statistical power, is typically scored out of a possible '5'. However, it was modified for this review to either a '0' or a '1' (power analysis reported). This approach has been used in previous literature (25). Two authors independently appraised the articles with their results provided to a third author who determined the level of interrater agreement using a Cohen's Kappa coefficient analysis. In the same manner as the reviewing process, any differences in final scores for each article were adjudicated by the third author if consensus could not be met. Next, a qualitative rating proposed by Kennelly was used to grade each study (17). The Kennelly grade was then converted into a percentage score to provide a final grade reporting the quality of the study. This was done by using the raw Downs and Black scores and dividing by 28, then multiplying by 100 to receive a percentage. Scores < 45.4% were deemed 'poor' methodological quality, while scores between 45.4% and 61% demonstrated 'fair' methodological quality. All scores > 61.0% were deemed to be of 'good' methodological quality (15).

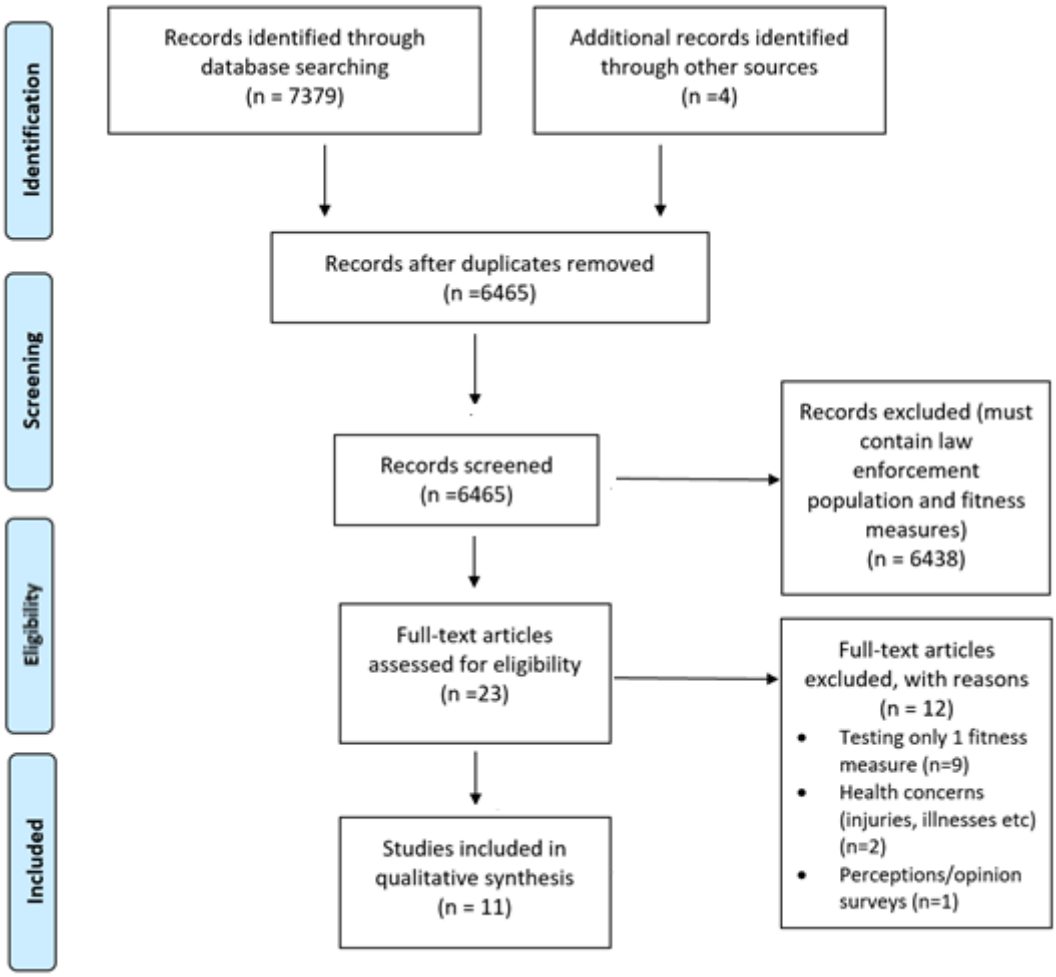

Figure 1: PRISMA (23) diagram summarizing the selection and screening process of the critical review

Table 2: Inclusion and Exclusion criteria applied to the literature search and examples

Inclusion Criteria	Examples
Must contain Law Enforcement Officers	Any study including police, cadets, recruits, patrol, incumbent officers
Must contain a fitness/physical measure	Any study containing a measure of fitness, i.e. 1-mile run, strength, power.
Must be within 15 year limitation to date of search	Study must be within the years of 1997-2018
Exclusion Criteria	**Examples**
Testing only one fitness measure	Studies including only one fitness measure, obstacle course
Health Concerns	Studies including injuries, illnesses, i.e. fractures, cardiac disease
Perceptions/opinion surveys	Studies including surveys on perceptions/options on fitness assessments

Data relevant to the research theme was extracted from each article, including fitness tests results and individual physical characteristics. Data extracted from the studies included author, year, title; any data on subject characteristics such as age, height, and body mass; any data

relating to fitness measures focusing on strength, power, endurance, flexibility, aerobic, anaerobic measures and agility. The definitions used to categorize the fitness measures were taken from the National Strength and Conditioning Association (1). Power was defined as the maximum amount of work per given unit of time; i.e. the ability of a muscle to exert force while contracting at high speed. Muscular endurance was defined as the ability of a certain muscle or muscle group to perform repeated contractions against a resistance less than maximal. Muscular strength was defined as the amount of force that may be exerted by an individual in one maximum muscle contraction. Anaerobic capacity was defined as the maximum amount of ATP (adenosine triphosphate) during a specific mode of short-duration maximal exercise. Aerobic capacity was defined as the maximum rate at which an individual can produce energy oxidation of energy resources. Flexibility was defined as the range of motion about a body joint. The ability to change the direction of body parts quickly and in a precise manner was known as agility. Extracted data is shown in Table 3.

Table 3: Fitness measure information extracted from each article

Author/ Year/ Title	Participants (Gender, Age, Weight, Height)	Measures and Key Findings	Critical Appraisal Score
Beck, A. Q., et al. (2015) (2) "Relationship of Physical Fitness Measures vs. Occupational Physical Ability in Campus Law Enforcement Officers."	*n* = 16 male campus LEOs A(y) = 33.1 ± 8.7 Weight = 87.2 ± 11.2 kg Height = 179.0 ± 7.9 cm	*Muscular endurance* Pushup (repetitions, *n* = 14) 34.8 ± 12.6 repetitions Curlup (repetitions, *n* = 14) 55.6 ± 45.9 repetitions *Muscular strength (kg)* Absolute 1RM bench press (*n* = 15) 93.1 ± 19.8 kg Absolute 1RM leg press (*n* = 16) 647.0 ± 116.4 kg Relative 1RM bench press (*n* = 14) 1.10 ± 0.30 kg Relative 1RM leg press (*n* = 15) 7.60 ± 1.63 kg Handgrip, left hand (kg, *n* = 15) 52.5 ± 5.9 kg Handgrip, right hand (kg, *n* = 15) 55.9 ± 6.4 kg *Muscular power* Vertical jump height (cm, *n* = 15) 51.4 ± 10.2 cm Relative vertical jump height (cm, *n* = 15) 0.60 ± 0.14 cm *Agility (seconds)* Agility test (*n* = 16) 18.2 ± 1.6 seconds *Aerobic endurance* Absolute V̇O2peak (ml/min, *n* = 14) 3.67 ± 0.45 L/min Relative V̇O2peak (ml/min/kg, *n* = 14) 42.7 ± 5.9 ml/kg/min *Flexibility* Sit and reach (cm, *n* = 16) 32.1 ± 9.8 cm *OPAT time (s)* Overall time (seconds) 107.2 ± 17.9 seconds Stair ascent/descent (seconds) 2.9 ± 0.6 seconds 159 m run (seconds) 42.8 ± 7.8 seconds Barrier manoeuvre (seconds) 16.7 ± 3.4 seconds Rescue/arrest (seconds) 22.3 ± 7.2 seconds Sprint (seconds) 2.8 ± 0.8 seconds 1. Agility, aerobic capacity and muscular endurance was correlated to occupational physical ability of campus LEOs. 2. Muscular strength, endurance, aerobic capacity and anaerobic endurance are important to officers when performing occupational tasks such as chasing and combative tasks. 3. Only the officers age was positively correlated to the overall OPAT time.	72% Good

Author/ Year/ Title	Participants (Gender, Age, Weight, Height)	Measures and Key Findings	Critical Appraisal Score
Cocke, C. et al. (2016) (7) "The Use of 2 Conditioning Programs and the Fitness Characteristics of Police Academy Cadets."	*n* = 61 male police cadets A(y) = 27.4 ± 5.9 Body Weight = 85.4 ± 11.8 kg	*Randomized Training Group (n = 50)* Bench Press (kg) 88.45 ± 23.69 kg Pushup (repetitions) 48.96 ± 15.15 repetitions Situps (repetitions) 33.96 ± 9.02 repetitions Vertical jump (cm) 55.32 ± 10.68 cm Power (W) 5235.01 ± 866.29 W Aerobic 2.4 km run (min) 12.54 ± 1.41 min Anaerobic 300-m sprint (seconds) 53.36 ± 4.98 seconds *Periodized Training Group (n = 11)* Bench Press (kg) 106.20 ± 15.15 kg Pushup (repetitions) 53.45 ± 14.40 repetitions Situps (repetitions) 42.27 ± 8.51 repetitions Vertical jump (cm) 55.32 ± 10.68 cm Power (W) 5979.54 ± 762.59 (W) Aerobic 2.4 km run (min) 11.49 ± 1.41 min Anaerobic 300-m sprint (seconds) 51.75 ± 4.18 seconds	73% Good

Author/ Year/ Title	Participants (Gender, Age, Weight, Height)	Measures and Key Findings			Critical Appraisal Score
Dawes, J. J., et al. (2017) (9) "Physical Fitness Characteristics of High vs. Low Performers on an Occupationally Specific Physical Agility Test for Patrol Officers."	*n* = 476 Male patrol officers A(y) = 39.7 ± 7.7 Weight(kg) = 93.9 ± 15.7 *n* = 19 Female patrol officers A(y) = 37.7 ± 8.6 Weight (kg) = 77.2 ± 12.8	*Variable* Est. VO2 (ml/kg/min) SU (repetitions) VJ (cm) MSFT (number) PU (reps) LBD (kg) HGD (kg) BMI PAT (sec) The multistage fitness test, number of situps and vertical jump height best predicted performance in the Physical Agility Test (PAT).	*Group 1 (Less fit officers)* 25.06 ± 3.27 27.84 ± 7.95 45.74 ± 7.46 24.05 ± 8.63 30.34 ± 11.71 168.74 ± 34.43 54.07 ± 9.05 30.37 ± 3.96 217.16 ± 18.33	*Group 2 (Fit officers)* 34.57 ± 4.99 40.97 ± 7.28 48.23 ± 7.57 52.05 ± 15.84 47.17 ± 12.93 172.74 ± 31.41 54.83 ± 7.69 26.15 ± 2.89 82.79 ± 19.06	72% Good
Dawes, J. J., et al. (2017) (10) "A physical fitness profile of state highway patrol officers by gender and age."	n = 597 Male state troopers A(Y) = 39.52 ± 8.09 Weight = 93.66 ± 15.72 kg Height = 180.72 ± 7.06 cm n = 34 Female state troopers A(Y) = 36.20 ± 8.45 Weight(kg) = 74.02 ± 14.91 Height = 169.62 ± 6.65 cm Group 1: Ages 20-29 Group 2: Ages 30-39 Group 3: Ages 40-49 Group 4: Ages 50-59 Group 5: Ages 60-69	*Measure* Vertical Jump (cm) Leg/Back Dynamometer (kg) Grip (kg) Pushups (repetitions) Situps (repetition) Shuttles (number) 1. General decline in mean performance between male officer age groups in weight, vertical jump, number of situp and pushups, and number of shuttles completed. 2. Females did not vary considerably across the age groups. 3. Body weight in male officers tend to increase with age. 4. Isometric strength tests were similar for the male and female officers across all age groups. 5. Older officers reported that previous injury or joint stress limited their ability to finish the MSF, not their aerobic fitness. 6. Certain physical characteristics may decline with age across both male and female law enforcement officers.	*Female Officers* 36.80 ± 5.69 116.53 ± 20.85 37.875 ± 5.34 24.24 ± 11.63 31.06 ± 9.52 26.19 ± 10.86	*Male officers* 50.74 ± 8.89 170.68 ± 37.46 55.04 ± 7.77 39.09 ± 15.61 34.46 ± 10.29 38.04 ± 19.87	74% Good

Author/ Year/ Title	Participants (Gender, Age, Weight, Height)	Measures and Key Findings		Critical Appraisal Score
Dawes, J. J., et al. (2016) (11) "Associations between anthropometric characteristics and physical performance in male law enforcement officers: A retrospective cohort study."	n = 76 Male LEOs A(Y) = 39.42 ± 8.41 Weight = 84.21 ± 12.91 kg All subjects belonged to a volunteer fitness program	*Measure*	*Cohort Mean ± SD N = 76*	75% Good
		Chest skinfold (mm)	13.74 ± 5.52 mm	
		Abdominal skinfold (mm)	24.57 ± 8.85 mm	
		Thigh skinfold (mm)	12.72 ± 4.99 mm	
		Sum of all skinfolds (mm)	51.01 ± 14.56 mm	
		Estimated body fat (%)	16.89 ± 4.60 %	
		Estimated lean mass (%)	70.21 ± 11.45 %	
		Estimated fat mass (kg)	14.24 ± 4.50 kg	
		Pushups (repetitions)	55.58 ± 17.35 repetitions	
		Situps (repetitions)	41.05 ± 6.96 repetitions	
		Vertical jump height cm)	61.26 ± 7.96 cm	
		Estimated peak power (W	5478.38 ± 829.96 W	
		Bench press (kg)	93.79 ± 25.91 kg	
		Bench press ratio (BPR)	1.10 ± 0.23 BPR	
		300 m (seconds)	56.03 ± 10.67 seconds	
		1.5 mile run (min:secs)	12.75 ± 2.30 seconds	
		Estimated VO2 max (ml/kg/min)	41.31 ± 6.50 ml/kg/min	
		1. Except for situps, 300-m run and 1.5 mile run, estimated body fat percentage was significantly and negatively correlated with all the other fitness measures. 2. For pushups, 1RM bench press, and vertical jump height, percentage of lean body mass was significantly and positively correlated. 3. From the results of this study, percentage of body fat or fat mass or lean mass is associated with physical fitness performance. 4. The percentage of lean mass may be more important than fat mass when measuring strength and muscular endurance. Conversely, fat mass is a greater predictor for aerobic fitness than lean mass. Correlations between lean mass and performance measures were stronger in strength, muscular endurance and power. Therefore, it suggests focusing on training to increase lean muscle mass to improve these areas of performance.	

Author/ Year/ Title	Participants (Gender, Age, Weight, Height)	Measures and Key Findings	Critical Appraisal Score
Lockie, R. G., et al. (2018) (21) "Are there similarities in physical fitness characteristics of successful candidates attending law enforcement training regardless of training cohort?"	Total *n* = 196 Male LEO candidates *n* = 30 Female LEO candidates *Cohort 1 n = 90* A(y) = 28 ± 60 Height (m) = 1.76 ± 0.09 Weight (kg) = 82.56 ± 11.38 *Cohort 2 n = 67* A(y) = 26 ± 50 Height (m) = 1.77 ± 0.08 Weight (kg) = 79.94 ± 11.54 *Cohort 3 n = 69* A(y) = 27 ± 70 Height (m) = 1.74 ± 0.10 Weight (kg) = 78.12 ± 12.96	Overall (*n* = 226) *Measure* Pushups (repetitions) = 40 ± 13 repetitions Situps (repetitions) = 40 ± 9 repetitions 75 PR (seconds) = 17.43 ± 1.23 seconds Arm Ergometer (revolutions) = 128 ± 18 revolutions 2.4 km run time (min:sec) = 12:57 ± 1:49 min:sec 1. No significant differences for maximal number of pushups and situps in 1 minute, time to complete the 75-yard pursuit run, number of revolutions on the arm ergometer test, time to complete 2.4-km run and age between the three cohorts. 2. Regardless of cohorts attending physical training programs to prepare for law enforcement agency (LEA) entry, candidates display similar levels of physical fitness.	75% Good

Author/ Year/ Title	Participants (Gender, Age, Weight, Height)	Measures and Key Findings	Critical Appraisal Score
Lockie, R. G., et al. (2018) (20) "Analysis of the effects of sex and age on upper and lower body power for law enforcement agency recruits before academy training."	*n* = 142 Male LEO recruits A(Y) = 27.46 ± 6.10 Height(m) = 1.76 ± 0.08 Weight (kg) = 82.54 ± 12.96 *n* = 37 Female LEO recruits A(Y) = 28.49 ± 6.52 Height (m) = 1.63 ± 0.06 Weight (kg) = 64.25 ± 7.88	*Male Recruits (n = 142)* VJ (cm) = 38.20 ± 10.34 cm PAPw (W) = 3,174.46 ± 744.40 W P:BM (W/kg) = 49.35 ± 9.90 W/kg MBT (m) = 4.01 ± 0.61 m RMBT (m/kg) = 0.063 ± 0.009 m/kg *Female Recruits (n = 37)* VJ (cm) = 54.36 ± 11.21 cm PAPw (W) = 4,984.20 ± 950.51 W P:BM (W/kg) = 60.60 ± 8.79 W/kg MBT (m) = 6.21 ± 0.99m RMBT (m/kg) = 0.076 ± 0.013 m/kg	73% Good

Author/ Year/ Title	Participants (Gender, Age, Weight, Height)	Measures and Key Findings	Critical Appraisal Score
Lockie, R. G., et al. (2018) (19) "The Physical Characteristics by Sex and Age for Custody Assistants from a Law Enforcement Agency."	*n* = 69 Male custody assistants A(y) = 27.53 ± 6.74 Weight (kg) = 81.27 ± 15.22 *n* = 39 Female custody assistants A(Y) = 28.56 ± 7.13 Weight (kg) = 65.68 ± 11.11	*Males* Grip Strength Left (kg) = 46.26 ± 15.22 kg Grip Strength Right (kg) = 47.96 ± 9.70 kg Pushups (repetitions) = 38.16 ± 12.29 repetitions Situps (repetitions) = 39.23 ± 10.88 repetitions 201 m run (seconds) = 34.51 ± 8.91 seconds 2.4 km run (min:sec) = 13:48 ± 3:12 min:sec VO2 max (ml/kg/min) = 40.29 ± 10.38 (ml/kg/min) *Females* Grip Strength Left (kg) = 31.91 ± 4.83 kg Grip Strength Right (kg) = 34.17 ± 6.28 kg Pushups (repetitions) = 18.54 ± 11.13 repetitions Situps (repetitions) = 33.67 ± 14.16 repetitions 201 m run (seconds) = 41.23 ± 6.03 seconds 2.4 km run (min:sec) = 16:30 ± 2:14 min:sec VO2 max (ml/kg/min) = 34.25 ± 6.94 ml/kg/min	77% Good

RESULTS

After the initial search, 7,379 articles were identified, following which 918 articles were removed as duplicates. Upon screening by title and abstract for relevance to the research topic, a further 6,438 articles were removed. The remaining articles were considered against both inclusion and exclusion criteria (Table 2), and a total of eleven articles met the inclusion, but not the exclusion criteria (2, 9-11, 19, 35, 40). The mean critical appraisal score was 74.36% (σ = 1.48) ranging from 68% (26) to 82% (40). The methodological quality, based on the Kennelly Grading System, was considered to be of 'good' quality (17). The level of agreement between the reviewers (k = 0.750) was considered a 'substantial agreement' (39). Of the 11 studies used in this review, two studies did not state the location where the research took place (10, 11). The remaining nine articles were from the United States (2, 7, 9, 19-21, 26, 35, 40). From the 11 studies used for this review, only two studies (2, 11) did not include female participants while the remaining nine studies had a combination of both male and female participants (7, 9, 10, 19-21, 26, 35, 40). Across the 11 studies included in this review, several components of fitness were measured using physical fitness tests. Elements of fitness measured included muscular endurance (2, 7, 9-11, 20, 21, 26, 35, 40), strength (2, 7, 9, 10, 20, 26), power (2, 7, 9-11, 19, 26), anaerobic fitness (7, 11, 20, 26), aerobic fitness (2, 7, 9-11, 20, 21, 26, 35, 40), occupation related fitness (2, 9, 21), and agility (2, 4, 9, 10, 21).

Muscle Endurance: Push-ups were the primary measure for upper body muscular endurance and were used in all but one study (19). Among the 10 studies that had included push-ups in their fitness assessment, all but one study used an approach in which the personnel being tested were to complete as many push-ups as they could within one minute (7, 9, 10, 19-21, 26, 35, 40). These studies had similar guidelines to successfully completing the assessment, with the subject starting in the "up" position with arms fully extended and then lowering down to a target whether a partner's fist, a sponge, or a bottle. The subject then returned back to the fully extended elbow "up" position and repeated this as often as possible in one minute (7, 9-11, 20, 21, 26, 35, 40). In the remaining article that included push-ups as part of the fitness assessment, there was no time constraint and law enforcement officers were directed to complete as many pushups as they could in succession to volitional fatigue (2).

Sit-ups were another common method of muscular endurance testing used in included studies to measure abdominal muscle endurance. The use of sit-ups was implemented in nine of the 11 studies (7, 9-11, 20, 21, 26, 35, 40). These studies had similar requirements for a successful sit-up, as patients would start in a supine position with knees bent to 90° and feet flat on the floor, held down by another person. The participant was then asked to complete as many sit-ups as possible in a one-minute period (7, 9-11, 20, 21, 26, 35, 40). Another study also measured abdominal muscle endurance using the curl-up test, which was a similar fitness measure to the sit-up. This study, however, did not limit the completion of this fitness test to one minute as it had allowed the participant to perform as many curl-ups as possible before reaching the point of fatigue (2). Additionally, the methodology to complete a curl-up was slightly different, whereby although adopting a similar starting position, the participant had their arms fully extended by their sides with their third digit positioned at the level of a piece of tape. A second piece of tape was

positioned 10 cm further than the first piece of tape. The participants were given the cue to complete a curl-up as many times as they could while their third digits touched the second piece of tape. The participants were to match the speed of a metronome set at 50 beats per minute (2).

Muscle Strength: Muscle strength was measured in a total of six studies (2, 7, 9, 10, 20, 26). Out of these six studies, five studies measured upper-body strength (2, 7, 9, 10, 20, 26). The most common strength measure between all included studies was hand grip strength, which was measured in four studies using a handgrip dynamometer (2, 9, 10, 20). Further, two studies implemented the use of a one-repetition maximum (1RM) bench press assessment to measure upper-body strength (7, 26). Another study also measured upper-body strength using a flat bench press, the test differed in that it did not measure the participant's 1RM bench press. Rather, the subject would start the test completing five repetitions of 60-80% of their estimated 5RM and the load would progressively increase by approximately 2.3-4.5 kg (with a 3-5 minute rest in between) until the subject could only complete between 2-5 repetitions with the weight on the bar (2). A similar methodology was used to conduct a lower body strength test using the leg press, but the load for the leg press was progressively increased by 6.8-9 kg until the subject could only complete between 2-5 repetitions (2). Finally, two studies analyzed isometric leg and back strength using a leg-back chain dynamometer to measure pulling force through the legs and back (9, 10).

Muscle Power: Lower-body power was the most reported measure of power in this review, and the vertical jump test was used in all of the seven studies that tested for lower-body power (2, 7, 9-11, 19, 26). Two of these seven studies assessed vertical jump height using the "Just Jump" apparatus (9, 10). The Just Jump technology calculates vertical height by measuring the length of time the participants' feet are not in contact with a 68.58 cm x 68.58 cm mat (10). The remaining five studies assessed vertical jump height using the Vertec apparatus (2, 7, 11, 19, 26). To measure vertical jump height using a Vertec apparatus, subjects were measured for their standing upward reach height before performing a countermovement jump as high as possible; the aim was for the subjects to displace the highest plastic fin on the device that they could at the apex of their jump (11). Out of the seven studies measuring vertical jump, only one study included an additional measurement of power by testing the ability of law enforcement recruits to generate isolated upper-body power using a medicine ball throw (19). For this test, the recruits sat against a wall with their legs outstretched in front of them on the ground and, utilizing a chest pass movement, these recruits projected a 2 kg medicine ball the farthest distance they could (19).

Anaerobic Capacity: A total of four studies assessed anaerobic fitness in study participants (7, 11, 20, 26). Out of these four studies, three used the 300-meter sprint test to test for anaerobic fitness capacity amongst subjects (7, 11, 26). The remaining study used a 201-meter sprint test as the anaerobic fitness assessment measure (20).

Aerobic Capacity: Aerobic fitness was a common measure used in studies included in this review, and the test that was most often used to assess aerobic fitness was the 2.4 km (1.5 mile) run test (7, 11, 20, 21, 26, 35, 40). Only one study included in this review did not assess aerobic capacity

of study subjects (19). Amongst the remaining 10 studies, only three studies did not use the 2.4 km run to measure aerobic fitness capacity (2, 9, 10). While two studies used the 20 Meter Multistage Fitness Test (9, 10), Beck and colleagues assessed for VO2 peak aerobic capacity using a metabolic cart to measure oxygen uptake of subjects on a treadmill with progressively increasing speed every two minutes until the subject had reached self-reported exhaustion (2). One study also tested the aerobic capacity of individuals with an upper body fitness test using an arm ergometer, in addition to the 2.4 km run (21).

Occupation Related Physical Testing: Three studies incorporated a job-specific measure of physical ability, focusing mainly on assessing the physical agility capacity of study subjects (2, 9, 21). One of these studies had study participants complete an occupation related physical ability test incorporating components of sprinting, direction changes, crawling, jumping, and overcoming barriers while wearing unspecified tactical gear particular to these campus law enforcement officers (2). The second study arranged a physical agility course that included a start from a seated position and then required the subject to stand up, run in a pattern requiring constant direction change for 30.48 meters, traverse through an obstacle of rings placed on the ground, complete a simulated victim rescue, jump through barriers, crawl, and push a sled for a distance of 14.64 meters (9). The participant was then required to repeat all these steps in the reverse order. The third study required study subjects to complete a "75-Yard Pursuit Run" which included linear sprints, direction changes, and stepping over barriers (21). This test simulated a "foot pursuit" scenario that may be similar to what study subjects would do as part of their occupation (21).

Agility: Only one study included a specific agility component to the fitness assessment that its participants completed (2). Although there were components of agility measured during occupation related physical assessments in studies included in this review (2, 9, 21), this study did not include other components of job related tasks, and asked participants to complete an agility course resembling a "Figure 8" pattern as fast as possible (2).

DISCUSSION

The purpose of this review was to analyze and critically appraise the available literature regarding fitness testing in the police force while documenting and comparing the findings of the fitness tests conducted in the studies. The fitness measures assessed in the studies included in this review were muscle endurance, muscle strength, muscle power, anaerobic fitness, aerobic fitness, occupation related fitness, and agility. The most common fitness tests employed across the 11 studies used in this review were the push-up, the sit-up, and the 2.4 km run.

It was evident from this review that push-ups were a commonly used test in many law enforcement agencies. This may be a beneficial test to include in a physical fitness battery particularly for police recruits as push-ups are a better measure of trunk muscular endurance when compared to sit-ups (11). Furthermore, a study by Beck et al. (2) found that push-up performance was related to several law enforcement occupational tasks. The push-up fitness test was also found to be a predictor of recruit success in police academy (35). A retrospective cohort

study analyzed the relationship between police academy graduation and fitness testing results (35). The fitness tests were comprised of push-ups completed in one minute, sit-ups completed in one minute, sit and reach scores, and a 2.4 km run. Out of these tests, the push-up test was among the two tests with the strongest association with graduation from the police academy (35). This may indicate that a strong performance on the push-up test may predict good performance on other physical fitness tests recruits have to complete to successfully pass academy training.

Another muscular endurance test that was commonly used for fitness testing in the law enforcement agencies discussed in this review was the sit-up test. Dawes et al. (11) found that sit-ups were different to other measures of muscular endurance in regard to anthropometric measures, as sit-ups had a stronger correlation with fat mass as opposed to lean muscle mass. This may indicate that poorer performance on sit-ups was more related to body fat distribution as opposed to muscular endurance, which the test is designed to assess (11). As such, conditioning to reduce fat mass, if required, in addition to muscular endurance training may improve sit-up performance.

The most common measure of muscle strength amongst the studies included in this review was handgrip strength. This measure of upper body strength was most commonly measured using a handgrip dynamometer. Interestingly, although grip strength is a commonly used measure of upper body strength in fitness assessments in law enforcement agencies, grip strength has also been shown to predict marksmanship amongst police officers (28). Due to the nature of firearm handling, an officer's ability to hold their firearm in a static position may be influenced by the grip strength of their non-shooting hand. Thus, officers with stronger grip strength in their non-shooting hand may also have better marksmanship in comparison to their colleagues with weaker grip strength.

Of research including muscle power, the most often reported measurement was that of lower body power, particularly the vertical jump test. Vertical jump height is a measure of fitness that has been shown to provide beneficial predictive information as to possible injury or illness risk in the tactical population (27). In a study conducted by Orr et al. (27) it was found that when compared to the group of subjects that performed best on the vertical jump test, the group that performed the worst had a three times greater risk for experiencing injury or illness. It was hypothesized in the study that the risk of injury may be due to several possible reasons including the association of lower vertical jump height score and neuromuscular fatigue which may cause altered biomechanics and lead to injury (27). Another possibility may be the need for those with lower vertical jump scores (and thus decreased lower body strength and power) to increase their training or performance intensity to match the intensity of police recruits with a higher amount of lower body strength and power (and thus a better vertical jump score) (27). Strong correlations between vertical jump scores, lower body strength scores, and sprinting scores have also been highlighted in previous literature (41). Although not significant, Beck at al. (2) found that vertical jump performance displayed strong trends in correlation to police occupational performance measures. This may indicate that a vertical jump test may be predictive of more

information in a physical fitness battery than just lower body power and could be used as a tool to ensure officers are healthy and fit to complete policing duties with minimized risk of injury.

Aerobic fitness testing was a measure of fitness that was assessed quite frequently in the studies included in this review. The most common measure of aerobic capacity amongst the studies in this review was the 2.4 km run. This is unsurprising as the 2.4 km run is assessed quite frequently amongst tactical personnel (6). It has been found that the 2.4 km run times, along with the push-up test, had the strongest association with graduation from the police academy (35). Given that aerobic fitness has been found to be predictive of injury risk in military trainee populations (18, 22, 32), these results support the potential use of aerobic fitness measures, like a 2.4 km run, as one screening tool to select candidates with the highest potential for training success.

The agility of officers was assessed either by a combination of occupationally specific tasks that also measured agility, or by having personnel complete a pure agility task. An example of a pure agility task would be completing a "Figure 8" course as fast as possible (2). Beck et al. (2) found strong positive correlations between agility tests and police occupational performance tasks. This finding is not unsurprising given that a law enforcement officer would most likely have to change direction suddenly if chasing a suspect (6). What is unexpected was the limited use of this measure in fitness testing batteries.

Given the commonality of some tests (e.g., 2.4 km run, push-ups, and sit-ups) across law enforcement, for example the relationships between some tests (e.g., 2.4 km run, and push-ups) and graduation success, and the relationships between some tests (e.g., push-ups, handgrip strength, and agility fitness tests) and occupational performance measures, a battery of fitness tests may be of benefit. Using a battery of tests inclusive of 2.4 km run, push-ups, and sit-ups will allow for comparisons of fitness levels between agencies and likewise inform graduation success potential. The addition of strength (e.g., handgrip strength) and agility (e.g., "Figure 8" course) can inform potential occupational performance capability. Finally, a battery of tests, can be used to identify which components of a recruit's fitness (e.g., aerobic fitness, muscular endurance, etc.) requires greater attention as well as inform the impacts of an academy physical training program on discrete fitness components.

However, prior to employing a battery of fitness tests, three considerations are needed. Firstly, the intent of the battery of fitness tests must be determined. For example, whether the tests are used to identify trainees at a greater risk of injury and graduation failure, as a measure of general fitness and health, or as a measure of occupational performance capability (31), must be determined as each of these intents may require different standards or even tests employed in the battery. Secondly, if the intent of the fitness battery is to predict injury, then an assessment that meets with agency's training focus is needed. Tomes et al. (37) found that aerobic fitness was a strong predictor of injury risk during training. However, the authors also noted that this is likely the case when the academy training involved a sufficient volume of running as part of its training program. As such, if the agency did little running during its academy, then a 2.4 km run assessment may not be the most appropriate assessment to determine injury risk during training. Finally, and perhaps most importantly, if the intent of the fitness test is to determine

whether the recruit will be fit enough to complete occupational tasks, then assessments that best mimic these tasks are needed. However, given the noted variances in occupational related testing identified in this review, future research is needed to determine which occupationally related tests are widely applicable to multiple agencies and as such which of these tests will be employed to allow for comparisons between agencies while concomitantly ensuring graduating officers are able to meet the physical requirements of policing.

Limitations to this literature review should be acknowledged. One notable limitation is the limited amount of available peer reviewed literature that is specifically related to fitness testing for the police population. While this is not anticipated to have affected this review as the studies included were of high methodological quality and common themes presented in the results and discussion were prevalent in these studies, further research is warranted for this topic to accommodate the sheer volume and variations in police departments. A second limitation to this review is the variety in measures of occupational-based performance in the studies. It is difficult to compare the studies that included occupational related testing, definitively, since these tests were not the same. As such, specificity to each measure could impact on the findings presented in this review.

CONCLUSIONS

This review found that the 2.4 km run (measure of aerobic fitness) and the push-up and sit-up tests (measures of muscular endurance) were the most common fitness measures conducted in the law enforcement studies. The vertical jump was a common assessment for lower body power and grip strength for upper body strength. Tests such as the 2.4 km run, and push-ups were strong predictors of police academy graduation potential. Push-ups, handgrip strength, and agility fitness tests were measures of physical fitness were correlated with occupational performance. Due to the high risk of cardiovascular disease in this population, the use of aerobic fitness measures (e.g., the 2.4 km run) may be of further benefit to assess fitness in law enforcement populations. Ultimately, given the diversity of fitness requirements and associations with injury risk, health, and occupational tasks, a battery of fitness tests, based on the intent of the tests (e.g., predicting injury, health, occupation performance, etc.) may be of most benefit.

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