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Fitness Profiles in Elite Tactical Units: A Critical Review

DANIEL MAUPIN†[1], THOMAS WILLS†[1], ROBIN ORR‡[2], and BEN SCHRAM‡[2]

[1]Bond Institute of Health and Science, Bond University, Gold Coast QLD, Australia; [2]Tactical Research Unit, Bond University, Gold Coast, QLD, Australia

†Denotes graduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 11(3): 1041-1062, 2018. Elite tactical units complete a variety of demanding tasks and a high level of fitness is required by this population to perform their occupational tasks optimally. The aim of this critical review was to identify and synthesize key findings of studies that have investigated the fitness profiles of elite tactical units. Included studies were critically appraised, using the Downs and Black checklist, and a level of evidence was determined. Relevant data were extracted, tabulated, and synthesized. Fourteen studies were included for review and ranged in percentage quality scores from 46% to 66% with a mean of 57.5%. Moderate interrater agreement (κ = 0.496) existed between raters. A variety of fitness measures were used across various domains of fitness. The most common measures were in the areas of anthropometric measures, strength, power, and aerobic capacity. However, there was high variety in the measures and their protocols. Though fitness appears to be a critical part of research and practice in tactical populations, currently there is no standardized measure or result for this population. Further research in fitness profiling should be completed using standardized outcome measures which cover the spectrum of the fitness demands for this population.

KEY WORDS: SWAT, special forces, strength and conditioning, police, military, adult, exercise

INTRODUCTION

Elite tactical units (ETUs), inclusive of military Special Forces (SF), and law enforcement Special Weapons and Tactics (SWAT) teams are at the forefront of national security and service. These units require their personnel to routinely perform at the highest level; above and beyond the expectations of civilians and regular tactical personnel (i.e. general soldiers or general-duties police officers) (38). Consequently, their training is typically more demanding than that of elite athletes (1). For example, to be able to complete their missions, personnel serving in ETUs must be able to successfully perform tasks while carrying significant loads (46). Previous research has identified that Australian Army soldiers carry up to an average of 48kg into unpredictable and hostile environments (35). Conversely, the SF members have been known to carry loads in excess of 55kg (49). Similarly, while general duties police officers are known to carry loads of around 10 kg (4), the loads carried by police ETUs can range from 22kg (7) up to 40 kg (26). This physical challenge highlights the importance of aerobic fitness, endurance, and anaerobic power for military and law enforcement personnel (36, 42). In Australia, ETUs are frequently deployed across a range of hostile environments, and a high level of fitness is necessary to undertake and perform complex tactical operations across a spectrum of field environments that include extreme heat, cold, or altitude (21, 28).

Fitness profiles are a collection of physiological measures employed to measure task-specific abilities. These profiles have even been used to predict performance in sporting environments (3). The physiological measures that inform these profiles can take into account the physical demands of a given task and have been shown to be useful in the design of programs that address specific weaknesses in fitness relative to task requirements. As such, these profiles can be used as selection criteria in situations where key tasks are known (2, 25). Whilst at present fitness profiles are used and accepted within professional sport, it is likely that there exists scope to extend the use of fitness profiles to ETU populations. Without a fitness profile – or similar model – the ability to facilitate accurate benchmarking in the training and assessment (in terms of readiness for active duty or deployment) of new ETU personnel or for those returning from injury is restricted (5).

Established fitness profiles for ETUs could underpin the creation of specific strength and conditioning programs, return to active duty guidelines, and inform recruit selection. Specific fitness profiles allow strength and conditioning programs to be tailored to each unit, and to mark measures that determine their success (3). Programs could subsequently be modified on an individual level, addressing areas of weakness within the individual subject's fitness profile as they relate to the profiles of the group or unit. Considering this approach it is not surprising that the National Strength and Conditioning Association (NSCA) note that fitness profiles, through specific measures, have demonstrated the ability to reduce the risk of reinjury (2).

As previously mentioned, fitness profiles have a wide range of applications, such as return from injury programs. For these reasons, the aims of this critical literature review were to identify, critically appraise, and synthesize key findings from the current body of knowledge on fitness levels within ETU populations through which to inform an ETU fitness profile.

METHODS

Protocol

Search Strategy: A two-tiered approach was employed to identify and include relevant studies to inform this review. The first tier consisted of a systematic search of key databases, completed on 18 August 2017. The databases searched were chosen based on their large number of peer-reviewed material in this area of interest and included Pubmed, Embase, and CINAHL. Search terms were carefully selected based on a preliminary review of relevant literature, and the shortlisting of re-occurring terms deemed relevant to the subject of this review. Once these key search terms were identified, the research team conducted searches using the terms and databases outlined in Table 1. Secondly, known researchers in this field sourced other studies of relevance from either grey literature or peer-reviewed full-text known to them. This process was used to capture studies that were not identified in the previous search due to their specific journals not being indexed with the databases. Where available, database filters were used to aid in only capturing research relevant to this review.

Following collection of all studies, duplicates were removed, and the remaining studies were screened by title and abstract for relevance. As with all reviews, there was a potential for search bias, duplication bias, inclusion criteria bias and selector bias (51). To minimize these biases, numerous strategies were employed. Search bias was limited via use of broad search terms to capture all studies, while duplication bias was limited during the first step of screening by removing all duplicates. Two reviewers (DM & TW) independently and separately screened and selected the studies to limit selector bias and ensure an objective selection. Lastly, inclusion and exclusion criteria (Table 2) were established prior to screening. The PRISMA diagram (32) (Figure 1) outlines the search process in its entirety.

Table 1. Databases and Relevant Search Terms.

Database	Search Terms	Filters	Results
Pubmed	("Police"[Mesh]) OR "Military Personnel"[Mesh] OR Tactical Athlete OR SWAT OR Special Weapons Unit OR Special Response Team) AND ("Exercise Test"[Mesh] or "Exercise"[Mesh] or Strength OR Power OR Load Carriage OR Military Fitness OR Physical Endurance OR Physiology OR Human Performance OR Agility OR Grip Strength OR Physical Readiness OR Occupational Demands OR optimization OR Conditioning or Tactical Strength and Conditioning)	Human, English	2187
Embase	('police'/exp OR 'soldier'/exp) AND ('exercise'/exp OR 'exercise test'/exp OR 'strength'/exp OR 'grip strength test'/exp OR 'resistance training'/exp OR 'agility'/exp OR 'rate of force development'/exp)	Human	1191
CINAHL	(MH "Exercise") OR (MH "Exercise Test") OR (MH "Physical Endurance") OR (MH "Exercise Test, Muscular") OR (MH "Physical Performance") OR (MH "Physical Fitness") OR (MH "Military Training") AND (MH "Military Personnel") OR (MH "Military Services") OR ((MH "Police"))	English	508

Quality Assessment: All included studies were then critically appraised using a modified Downs and Black checklist (18). This checklist is a twenty-seven question assessment that analyses the methodological quality of a study and provides an overview of the strengths and weaknesses of the study (18). It has previously been validated for use in studies on tactical populations (8, 10, 30). Due to the subjectivity of question twenty-seven (19), the Downs and Black checklist was modified for this review. Specifically, the question regarding statistical power was modified from its original six-point scale, to a two-point scale. This modification has previously been used in research to minimize the inherent subjectivity (19). One point was awarded if the authors reported a sample size or power analysis, while zero points were awarded if sample size or a power analysis were not mentioned. This modified approach reduced maximum possible points from the original 32, to 28.

Table 2. Inclusion and exclusion criteria and examples of excluded studies.

Inclusion Criteria	**Example/s**
Must contain tactical population	Any study including police, military, firefighters
Must contain adult population	Any study containing adults, in this case being over the age of 18
Must contain a fitness measure	Any study containing a measure of fitness, ie strength, power, or aerobic fitness
Exclusion Criteria	**Example/s**
Health Concerns	Studies including traumatic brain injury or heat stroke
Health Intervention	Studies including nutritional supplementation or blood infusion
Non-elite	Studies including general military force or general police
Systematic Review	Studies presented as systematic reviews
Graphic representation of data	Studies that did not present data as raw number
No full text	Studies whose full texts could not be found

The Downs and Black critical appraisal was completed by two authors (DM & TW) working individually and separately to minimize bias. The level of interrater agreement was then calculated by a third author (RO) via Cohen's Kappa coefficient ($\varkappa$). The Critical Appraisal Scores (CAS) were then finalized, by using the average of the two final scores. The studies were then graded using qualitative ratings proposed by Kennelly (23). The Kennelly system, which was originally established using the Downs and Black scoring system of 32 points, was converted to a percentage-based score to enable comparable grading of the modified Downs and Black scores, with < 45.4% signifying 'poor' methodological quality, between 45.4% and 61.0% showing 'fair' methodological quality, and >61.0% demonstrating 'good' methodological quality (23).

Data Extraction: After the final studies were selected, appraised, and graded, key data were extracted. Given that either very few or no research papers specifically profiling the fitness of ETUs were expected, data extraction of physiological measures used in ETU studies was used to inform the profiles of ETUs. This was a key consideration during the extraction process. Data extracted included author and year of paper; any data pertaining to patient characteristics, anthropometric measures, strength, power, endurance, flexibility, aerobic measures, agility and speed. The definitions used to categorize the fitness measures were taken from the National Strength and Conditioning Association (3). Anthropometric measures were defined as the measurements applied to the human body and generally included measurements of height, weight, and selected body and limb girths. Muscular strength was defined as the force a muscle or muscle group can exert in one maximal effort and that could be quantified as the maximum weight lifted once. Power was defined as the ability of a muscle to exert high force while contracting at high speed. Endurance was defined as the ability of a certain muscle or muscle group to perform repeated contractions against a submaximal resistance.

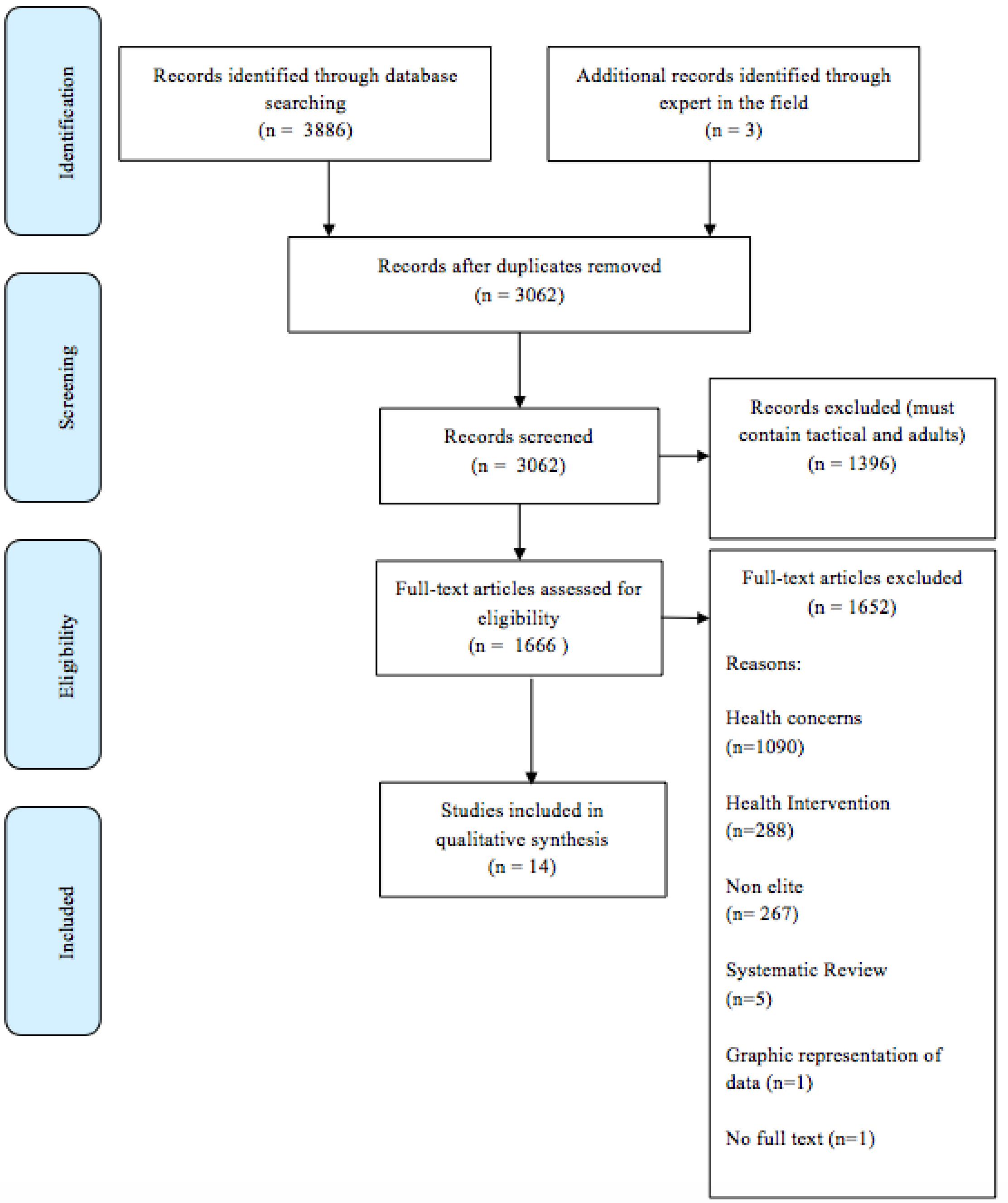

Figure 1. PRISMA (32) diagram detailing the screening process of the literature review.

Flexibility was defined as the range of motion about a body joint. Aerobic capacity was defined as the maximum rate at which an athlete, or specific to these papers tactical personnel, can produce energy oxidation of energy resources. Agility was defined as the ability to stop, start, and change the direction of the body or body parts rapidly and in a controlled manner. Speed was defined as a displacement per unit time, typically quantified as the time taken to cover a fixed distance.

Statistical Analysis

In instances where a measure was reported in only one study, the mean value for that measure was reported. For measures reported in more than one study, a 'mean of means' was determined by adding all the means together and dividing by the number of means for that fitness measure. In addition, the lowest mean of the studies and the highest mean of the studies using that measure were included to demonstrate the range of means.

RESULTS

Search Results: After the use of specific inclusion and exclusion criteria (Figure 1), 14 studies were included for review. Of the fourteen included studies, 11 studies included various forms of military special forces (16, 17, 25, 31, 33, 34, 43-46, 48), while three included members of elite police units (11, 12, 38). Six studies were from the United States (11, 12, 33, 34, 38, 43), two from both Croatia (31, 48) and Tunisia (16, 17), and one each from Germany (46), Australia (25), England (44), and Norway (45). Eight studies reported only have male participants (12, 16, 25, 31, 33, 34, 38, 44), while in the remaining six studies gender was not specifically identified (11, 17, 43, 45, 46, 48). Three of the included studies were also identified from an expert in the field and not a part of the original search strategy (11, 12, 25).

Critical Appraisal Results

The Cohen's kappa analysis revealed a moderate agreement between raters (k = 0.496) (52). Raters disagreed most frequently on questions 4, 8, 10, 16, 17, 19, 21, and 26. This is likely due to the inherent subjectivity of these questions, as well as study design. The average score of the studies was 57.5% indicating fair quality with the lowest score of 46% (31) and the highest score of 68% (43) (see Table 3). Studies were consistently given lower scores in the areas of internal validity. This is likely due to the fact that none of the included studies were randomized-control studies and as such no blinding was implemented and therefore lower scores were awarded. Considering the focus of this review, the lack of randomization is not anticipated to impact on the profiles being established. However, as the raters were not blinded during the data collection, an internal bias, whereby higher scores were expected may have occurred.

Table 3. Key fitness profile information from each article

Article & Population	Subject Information	Anthropometric Measures	Strength	Power	Endurance	Flexibility	Aerobic Capacity	Agility	Speed	Evidence Score & Quality
Pryor et al. 2012 Pop = SWAT	n = 11 A (y)= 36.50 ± 6.30 H (cm)= 177.80 ± 6.10 W (kg)= 85.80 ± 9.50	BMI (kg/m2) = 27.10 ± 2.50 BF (%)= 18.00 ± 3.00	1 RM LP (kg)=243.40 ± 32.70 1 RM BP (kg)= 105.60 ± 16.20 1 RM SP (kg)= 68.20 ± 11.60	VJ (cm)= 41.80 ± 5.30	Back extensor hold (s)= 49.30 ± 13.90	Sit and reach (cm)= 75.00 ± 23.90 R lunge (cm)= 145.60±11.00 L lunge (cm)= 148.70 ± 9.10 R hip ext. (∘) = 20.50 ± 21.00) L hip ext. (∘) = 21.40 ± 6.60 R DF (∘)= 13.00 ± 12.40 L DF (∘)= 12.40 ± 3.30 R PF (∘)= 64.80 ± 6.30 L PF (∘)= 64.20 ± 8.20	VO2max (ml/kg/min) = 45.30 ± 6.10	N/A	N/A	54% Fair
Sporis et al. 2012 Pop = Croatian Special Operations Battalion	n = 13 A (y)= 31.23 ± 4.66 H (cm)= 180.53 ± 7.35 W (kg)= 82.88 ± 10.82	BF (%) = 12.45 ± 4.84	1RM BP (kg) = 90.38 ± 20.25	MBT (cm) = 31.87 ± 2.30 SBJ (cm) = 234.56 ± 21.04	2 min sit up test (reps) = 62.46 ± 11.44 2 min push up test (reps) = 56.46 ± 14.71	Sit and Reach (cm) = 13.57 ± 6.23	300 yard Run (s) = 66.61. ± 3.65 3200 Running (s) = 854.38 ± 64.02	N/A	20m Sprint (s) = 3.75 ± 0.12	66% Good
Dawes et al. 2015 Pop = SWAT	n = 21 A (y) = 36.05 ± 4.06 H (cm) = 175.44 ± 6.34 W (kg) = 93.25 ± 9.44	BMI (kg/m2) = 30.10 ± 3.20	Leg/back (kg) = 117.20 ± 29.40	VJ (cm) = 55.40 ± 6.70 Peak Power (W) = 5531.63 ± 587.93 Power: weight (w) = 59.45 ± 4.63 Power: Lean mass (w) = 74.01 ± 5.28	N/A	N/A	N/A	N/A	5-meter sprint (s) = 1.17 ± 0.07 10-meter sprint (s) = 1.94 ± 0.08 20-meter sprint (s) = 3.25 ± 0.13	57% Fair

Article & Population	Subject Information	Anthropometric Measures	Strength	Power	Endurance	Flexibility	Aerobic Capacity	Agility	Speed	Evidence Score & Quality
Dhahbi et al. 2016 Pop = Tunisian National Guard commandos	n = 21 A (y) = 24.09 ± 1.81 H (cm) = 179.52 ± 3.98 W (kg) = 74.90 ± 5.08	BMI (kg/m2) = 23.26 ± 1.65	N/A	Absolute power output (W) = 251.13 ± 73. Relative power output (W) = 3.33 ± 0.85	N/A	N/A	N/A	N/A	Time (s) = 15.55 ± 3.48	55% Fair
Dawes et al. 2014 Pop = SWAT	n = 21 A (y) = 36.05 ± 4.06 H (cm) = 175.44 ± 6.34 W (kg) = 93.25 ± 9.44	BMI (kg/m2) = 30.10 ± 3.20 Chest SF (mm) =14.52 ± 3.82 Abdominal SF (mm) = 32.19 ± 10.04 Thigh SF (mm) = 16.86 ± 5.24 SF sum (mm) = 63.57 ± 15.78	N/A	N/A	2 min push up (reps) = 64.50 ± 14.06 Max pull ups (reps) = 7.67 ± 6.04 2 min sit up test (reps) = 56.52 ± 12.89	N/A	Obstacle Course (s) 226.70 ± 10.94	N/A	N/A	57% Fair
Hunt et al. 2013 Pop: Australian Army Special Forces	n = 39	N/A	Sit ups (level) = 4.60 ± 1.30	VJ (cm) 55.70 ± 7.10	Push ups (reps) = 69.00 ± 12.00 Med ball Heaves (reps) = 12.00 ± 2.00	Sit and Reach (cm) = 31.20 ± 5.90	5 km March (minutes) = 45.20 ± 2.40 3.2 km battle run (minutes) = 15.00 ± 0.70 20 km March (minutes) = 182.90 ± 9.00 Maximal Aerobic capacity (ml/kg/min) = 55.10 ± 3.30 400m swim (min) = 8.60 ± 1.20	5 cone drill (s) = 8.10 ± 0.60	N/A	63% Good

Article & Population	Subject Information	Anthropometric Measures	Strength	Power	Endurance	Flexibility	Aerobic Capacity	Agility	Speed	Evidence Score & Quality
Nindl et al. 2007 Pop = U.S. Army Rangers	n = 50 A (y)= 24.60 ± 4.10 H (cm)= 176.10 ± 7.80 W (kg)= 78.40 ± 8.70	BMI (kg/m2) = 25.60 ± 4.20 LBM (arms) (kg) = 7.90 ± 1.00 LBM (legs) (kg) = 22.50 ± 2.80	Machine simulated clean (kg) = 81.50 ± 13.30	VJ (cm) = 44.10 ± 7.40 Peak Power (W) = 3972 .00 ± 561.00	N/A	N/A	N/A	N/A	N/A	52% Fair
Males et al. 1999 Pop = Croatian Army Special Unit	n = 35 A (y) = 22.00	N/A	N/A	N/A	Horizontal bar bents (reps) = 6.60 ± 3.17 Bent Hangs (reps) = 9.48 ± 3.95 Bents with bar (reps) = 30.68 ± 10.74 Knee-bents (reps) = 33.88 ± 8.78	N/A	600m cross country (min) = 33.37 ± 3.30 1500m run (min) = 6.03 ± 0.32 300m swim (min) = 6.43 ± 0.51 Obstacle course (min) = 3.45 ± 0.22: Forced march w/ weight (min) 142.44 ± 19.87:	N/A	N/A	46% Fair
Solberg et al. 2015 Pop = Norwegian Navy Special Operation Forces	n = 22 A (y)= 28.00 ± 4.00 H (cm)= 182.00 ± 6.00 W (kg)= 79.40 ± 5.10	BF (%)= 11.50 ± 2.70 LBM (%) = 51.00 ± 2.00	1RM LP (kg) = 300.00 ± 38.00 1RM BP = 104.00 ± 11.00kg Pull Ups(reps) = 9.00 ± 4.00 Brutal Bench (reps) = 14.00 ± 3.00	MBT (m) = 3.90 ± 0.40 CMJ cm = 41.40 ± 3.10 Standing LJ (cm) = 234.00 ± 16.00	N/A	FMS = 18.00 ± 2.00	VO2max (ml/kg/min) = 60.00 ± 4.2 3000m run min = 11.10 ± 1.00 EVAC test (s) = 49.00 ± 8.00	5-10-5 (s) = 5.20 ± 0.20	N/A	63% Good

Article & Population	Subject Information	Anthropometric Measures	Strength	Power	Endurance	Flexibility	Aerobic Capacity	Agility	Speed	Evidence Score & Quality
Muza et al. 1987 Pop = U.S. Army Special Forces	n = 12 A (y) = 27.30 ± 5.70 H (cm) = 180.50 ± 7.10 W(kg) = 79.40 ± 11.40 Surface area (m2) = 2.00 ± 0.17	BF Fat skinfold (%) = 15.70 ± 4.60 BF Fat underwater weight (%) = 15.10 ± 4.00 LBM (kg)= 67.20 ± 8.00	N/A	N/A	N/A	N/A	HR (bpm) = 188.00 ± 10.00 VO2 = 37.00 ± 3.00 Max O2 uptake (L/min) = 4.36 ± 0.56 Max O2 uptake (ml/kg/min) = 55.20 ± 4.30 Max O2 uptake (ml/kgLBM/ min) = 65.00 ± 4.60	N/A	N/A	54% Fair
Sharp et al. 2008 Pop = U.S Army 10th Mountain Division	n = 110 A (y) = 23.10 ± 4.70 H (cm) = 177.50 ± 6.70 W (kg) = 83.80 ± 14.70	FFM (kg) = 62.80 ± 7.30 BF (%) = 17.70 ± 6.40 BF (kg) = 15.10 ± 7.50 Bone mineral content (g) = (3550.00 ± 475.00) BMD (g/cm3) = 1.31 ± 0.08	Lifting strength (kg) = 74.60 ± 12.90	Upper body power (2kg med ball put n=109) 2kg meg ball put (cm) = 678.90 ± 80.40 VJ (cm) =51.20 ± 9.00	N/A	N/A	Peak VO2 (n=103) (l/min) = 4.22 ± 0.53 Peak VO2 (n=103) (ml/kg/min) = 50.80 ± 6.10	N/A	N/A	68% Good

Article & Population	Subject Information	Anthropometric Measures	Strength	Power	Endurance	Flexibility	Aerobic Capacity	Agility	Speed	Evidence Score & Quality
Sperlich et al. 2011 Pop = U.S. Special Forces	n = 120 A (y) = 28.90 ± 5.20 H (cm) = 183.30 ± 6.20	BMI (kg/m2) = 24.20 ± 1.60	N/A	N/A	N/A	N/A	Vo2 Peak (ml/min) = 57.40 ± 4.30 Vo2 Peak (ml/min/kg^-1.0) = 57.40 ± 4.20 Vo2 Peak (ml/min/kg^-(0.75) = 172.30 ± 12.60 Peak lactate concentration (mmol/L) = 9.30 ± 1.9- Peak HR (bpm) = 190.00 ± 7.00 Running economy at 3.20 m/s (ml/min) = 3210.00 ± 378.00 RE at 3.20 m/s (ml/min/kg^-1.0) = 39.40 ± 3.20 RE at 3.20 m/s (ml/min/kg^-0.75) = 118.40 ± 10.70	N/A	Vmax (m/s) = 4.54 ± 0.21 VLT (m/s) = 3.31 ± 0.11	52% Fair

Article & Population	Subject Information	Anthropometric Measures	Strength	Power	Endurance	Flexibility	Aerobic Capacity	Agility	Speed	Evidence Score and Quality
Simpson et al. 2017 Pop = British Special Air Service	n = 17 A (y) = 25.90 ± 4.30 H (cm) = 180.10 ± 6.30 W (kg) = 79.30 ± 6.50	N/A	N/A	N/A	N/A	N/A	VO2 Peak (L/min) = 4.34 ± 0.38 Vo2 Peak (ml/kg/min) = 55.00 ± 5.20 Max HR (BPM) = 196.00 ± 10.00 Max Blood lactate (mmol/L) = 9.80 ± 1.70 Max Treadmill time (min:s) = 23:30.00 ± 0:52.00 8miles backpack time (h:min:sec) = 1:28:38.00 ± 0:04:27.00 Ve (L/min) = 126.80 ± 12.90 Ve/VO2 = 31.90 ± 2.20 RER = 1.16 ± 0.08 HR (bpm) = 191.00 ± 1.00 HR% of peak (%) = 97.00 ± 1.70 Blood lactate (mmol/L) = 9.80 ± 1.70	N/A	N/A	54% Fair

Legend: Pop: Population, A: Age, H: Height, W: Weight, BMI: body mass index, 1RM: one repetition maximum, LP: leg press, BP: bench press, SP: shoulder press, VJ: vertical jump, MBT: medicine ball toss, R: right, L: left, Ext: extension, DF: dorsiflexion, PF: plantarflexion, SF: skin fold, HR: Heart Rate, VO2: volume of oxygen, N/A: no measures taken for this particular study, HGS: hand grip strength, BF: body fat, LBM: lean body mass, SBJ: standing broad jump, CMJ: countermovement jump, LJ: long jump, FMS: functional movement screen, EVAC: evacuation test, RER: respiratory exchange ratio, HR: heart rate, FFM: fat free mass, BMD: bone mineral density

Anthropometric and Fitness Measures: The most common measures taken were anthropometric measures, specifically BMI (body mass index) and body fat percentage, which were reported in 11 out of 14 studies (11, 12, 16, 17, 33, 34, 38, 43, 45, 46, 48) and aerobic measures which were reported in 10 out of 14 studies (11, 25, 31, 33, 38, 43-46, 48). The next most common tests performed were assessing power, reported in nine studies (12, 16, 17, 25, 34, 38, 43, 45, 48), followed by strength, assessed in eight studies (12, 17, 25, 34, 38, 43, 45, 48), and muscular endurance, in seven studies (11, 17, 25, 31, 38, 45, 48). The least common tests were flexibility, measured in only four studies (25, 38, 45, 48), speed, also reported in four studies (12, 16, 46, 48), and agility, in only two studies (25, 45). However, the protocols through which these fitness assessment data were collected in the studies varied. Considering these potential protocol differences, which will be discussed later in the text, Table 4 presents an overview (minimum, mean of means and maximum) of the anthropometric and fitness measures.

Table 4. Summation of anthropometric and fitness measure results

Measure	Minimum	Mean of Means	Max
BMI (kg/m2)	23.26 (16)	25.20	30.10 (11, 12)
BF (%)	11.50 (45)	15.08	18.00 (38)
1RM Bench Press (kg)	90.38 (48)	99.90	105.60 (38)
1RM Leg Press (kg)	243.40 (38)	271.7	300.00 (45)
Vertical Jump (cm)	41.80 (38)	49.60	55.70 (25)
Med Ball Put (cm)	31.87 (48)	386.40	678.90 (43)
Long Jump (cm)	234.00 (45)	234.28	234.56 (48)
Peak Power (W)	251.13 (16)	3251.69	5531.63 (12)
Pull Ups (reps)	7.67 (11)	8.34	9.00 (45)
Sit Ups 2min (reps)	56.52 (11)	59.49	62.46 (48)
Push Ups 2min (reps)	56.46 (48)	60.48	64.50 (11)
Sit and Reach (cm)	13.57 (48)	39.92	75.00 (38)
Relative VO2Max (ml/kg/min)	45.30 (38)	53.95	60.00 (45)
Absolute VO2Max (L/min)	4.22 (43)	4.40	4.67 (46)

(Reference to the associated study)

BMI (mean of means=26.20 ± 2.96 kg/m^2; range of means=23.26 kg/m^2 (16) - 30.10kg/m^2 (11, 12)) was calculated using similar protocols across all included studies (11, 12, 16, 17, 34, 38, 46). However, body fat percentage (mean of means=15.08 ± 2.65%; range of means=11.50% (45) – 18.00% (38)) was measured using either skinfolds (38), equation of Siri (48), underwater weighing (33), electrical impedance (45), or DEXA (43).

Strength was calculated in various manners across all studies. One repetition maximum tests of various exercises, such as bench press (mean of means=99.90 ± 8.36kg; range of means=90.38kg (48) - 105.60kg (38)) (38, 45, 48), shoulder press (mean=68.20kg) (38), and leg press (mean of means=271.70 ± 40.02kg; range of means=243.40kg (38)- 300.00kg (45)) (38, 45) were used, as well as a bench press estimated one repetition maximum test (mean=80.65 kg)

(17). Other measures of strength included hand grip strength (R Hand mean=56.24kg, L Hand mean=53.57 kg) (17), sit ups of increasing difficulty (mean=level 4.60) (25), leg/back chain dynamometer, a device which measures isometric strength as the participant lifts as if performing a deadlift (mean=117.20kg) (12), machine simulated clean (mean=81.50kg) (34), and "Brutal Bench", where subjects were suspended vertically from an abdominal bench with knees bent to 90 degrees and ankles secured while holding onto a rope behind their neck and pulling up so their elbows contact their knees (mean=14.00 reps) (45).

Power was also measured in various ways including vertical jump (mean of means=49.60 ± 6.41cm; range of means=41.80 cm (38) - 55.70 cm (25)) (12, 25, 34, 38, 43), medicine ball put (mean of means=386.40 ± 267.50 cm, range of means=31.87 cm (48)- 678.90 cm (43)) (17, 43, 45, 48), countermovement jump (mean=41.40 cm) (45), standing long jump (mean of means= 234.28 ± 0.39 cm; range of means=234.00 cm (45) - 234.56 cm (48)) (45, 48), peak power (mean of means=3251.69 ± 2712.96W; range of means= 251.13W (16) - 5531.63W (12)) using Sayers equation (12), Harman Formula (34), or an absolute and relative power output equation (16).

Muscular endurance was measured by either a back extensor hold (mean=49.30 s) (38), max pull ups (mean of means=8.34 ± 0.94 reps; range of means=7.67 reps (11)– 9.00 reps (45)) (11, 45), pull ups in 15 seconds (mean=10.91 reps) (17), pushups in 15 seconds (mean=18.33 reps) (17), horizontal bar bends, defined as lifting the body by the arms for the chin to each bar level with body in vertical position (mean=6.60 reps) (31), bent hangs, defined as descending from straight hang, with elbows bent for the shoulder to touch the hand on the bar, thereafter lifting the body to stretch the arms out (mean=9.48 reps) (31), bends with bar, lying on the back with feet fixed, lifting the trunk to sitting position, (mean=30.68 reps) (31), knee bends with 30kg, defined as having weight on the back and slightly astride, descending to crouch, then lifting the body to stretch the legs (mean=33.88 reps) (31), sit ups in 2 minutes (mean of means=59.49 ± 4.20 reps; range=56.52 reps (11) - 62.46 reps (48)) (11, 48), pushups in 2 minutes (mean of means=60.48 ± 4.20 reps; range of means=56.46 reps (48) - 64.50 reps (11)) (11, 48), pushups with a 2 second cadence (mean=69.00 reps) (25), and med ball heaves with a 4 second cadence (mean=12.00 reps) (25).

Flexibility was measured by sit and reach (mean of means=39.92 ± 31.63 cm; range of means=13.57 cm (48) – 75.00 cm (38)) (25, 38, 48), lunge distance (R Lunge mean=145.60 cm, L Lunge mean=148.70 cm) (38), hip extension based on distance from stepping test (R Hip mean=20.50°, L Hip mean=21.40°) (38), goniometry of the ankle (R DF mean=13.00°, L DF mean=12.40°, R PF mean=64.80°, L PF mean=64.20°) (38) and FMS 8 test version (mean=18.00) (45).

A range of measures of aerobic fitness were performed including treadmill based aerobic testing using the VO_{2Max}, both relative (mean of means=53.95 ± 5.21ml/kg/min; range of means=45.30ml/kg/min (38) – 60.00ml/kg/min (45)) (33, 38, 43-46) and absolute (mean of means=4.40 ± 0.19L/min; range of means=4.22L/min (43) - 4.67L/min (46)) (33, 43, 44, 46), a 3200m (mean of means=14.60 ± 0.57 min; range of means=14.20 min (48)- 15.00 min (25)) (25,

48) and 3000m run (mean=11.10 min) (45), a 1500m run (mean=6.03 min) (31), a 600m cross country run (mean=33.37 min) (31), a 300 yard run (mean=66.60 s) (48), a 400m (mean=8.60 min) (25) and a 300m swim (mean=6.43 min) (31), an evacuation test (mean=49.00 s) (45), various versions of an obstacle course (mean of means=3.61±0.23 min; range of means=3.45 min (31)- 3.77 min (11)) (11, 31), a 20 km march (mean=182.90 min) (25), an 8 mile backpack run (mean=1:28:38 hrs) (44), a forced march (mean of means=93.82 ± 68.76 min, range of means=45.20 min (25) - 142.44 min (31)) (25, 31) and a 3.2 km battle run (mean=15.0 min) (25). Three studies that reported VO_{2Max} results also reported other figures such as RER, blood lactate and heart rate among others (33, 44, 46).

Agility was measured in a variety of ways including a 5-10-5 shuttle test by Solberg (45) and a 5-cone drill where each cone was placed 3m apart in a zigzag pattern by Hunt (25). The average of the 5-10-5 shuttle test was 5.20 seconds, while the average of the 5-cone drill was 8.10 seconds. Finally, speed was measured via a 20m sprint (mean of means=3.50s, ± 0.353s; range of means=3.25s (12)- 3.75s (48)) (12, 48), 10m sprint (mean=1.94s) (12), 5m sprint (mean=1.17s) (12), max velocity during treadmill step protocol to physical exhaustion (mean=4.54 m/s) (46), or a 5m rope climb time (mean=15.55s) (16).

DISCUSSION

The aims of this critical literature review were to identify, critically appraise, and synthesize key findings from the current body of knowledge on fitness levels within ETU populations to inform an ETU fitness profile. This review found that the research was generally of 'fair' quality. Furthermore, the research came from a wide variety of countries and included a wide variety of measures although there were some commonalities.

Literature Quality: With an average of 57.5%, the overall quality of the research presented in this review is of fair quality based on the Kennelly grading system (23). likely due to the consistently lower scores given in the internal validity section of the Downs and Black scoring tool, due to the studies not being randomized control trials (18). However, it is important to note that the overall quality of the included studies is still graded as fair (23) and is acceptable for the purpose of profiling fitness levels as the lack of randomization is not considered to have had a negative impact on the ability to withdraw specialist data in order to inform ETU fitness profiles.

Anthropometric Measures: Despite BMI being calculated similarly across all studies. specialist police officers possessed the three highest scores, possibly due to physical demands and of specialist police populations compared to elite military, who tend to carry heavier loads (49), and may experience periods of caloric deficit and limited sleep (34). A higher BMI may significantly affect performance in multiple areas including muscular strength, muscular endurance, muscle power, aerobic capacity, and load carriage performance (13, 40). The findings in these specialist police officers highlight a potential concern noted amongst law enforcement, whereby police officers are known to suffer a higher rate of cardiovascular disease than the general population (39).

Body fat percentage was measured using a range of different techniques and therefore, direct comparison is difficult. With dual-energy X-Ray absorptiometry (DEXA) being considered a gold standard for measuring body composition (55), the findings of the study by Sharp et al. (mean=17.70 ± 6.40% (43)) can be viewed as a more accurate representation of the body fat percentage measures. Considering these limitations, these results suggest that specialist police officers have a higher BMI and body fat percentage compared to elite military units, though the results between Pryor et al (mean = 18.00%), measured via 3-site skinfold (38), and Sharp et al. (mean of 17.70%), measured via DEXA, (43), suggest a similar result. These results suggest that elite tactical units generally possess a lower body fat percentage (mean of means=15.08% ± 2.65% (33, 38, 43, 45, 48)) than the general population (20.10% (15)), general police (18.50% (6)), and general military (17.30% (40)).

Muscular Strength: Measures of strength also varied notably in the various studies, which makes direct comparison difficult, and reasoning was not always explained (12, 45). When comparing 1RM Bench Press, Pryor et al. demonstrated similar results (105.60 kg) (38) to the elite specialists studied by Solberg et al. (104.00 kg) (45), and higher results than the commandos in the study by Dhahbi et al. (80.65 kg) (17), who utilized an estimated 1RM. The similarities in strength were not supported by the leg press results as the special forces military population in the study by Solberg et al. demonstrated higher leg press results (300.00 kg) (45) compared to the specialist police population in the study by Pryor et al. (243.40 kg) (38), which may be due to different occupational demands as military forces tend to carry heavier loads than police forces (35). However, these differences may also be attributable to differences in testing procedure, and these studies did not go explain in enough depth in their leg press procedures to allow for comparison (38, 45). When looking specifically at 1RM Bench Press, it can be seen that these results are higher than those in the general population (88.90 kg (27)), while similar to those in the general police (96.30 kg (6)) and general military (100.90kg (54)), suggesting that these elite tactical units have higher muscular strength than the general population, and similar muscular strength than those in a general police or general military unit.

Power: Power was also measured using various methods, including a vertical jump and a medicine ball throw. Measurements taken in the specialist policing population (41.80 cm and 55.40 cm) (12, 38) were comparable to those found in elite military populations (44.10 cm and 55.70 cm) (25, 34), demonstrating similar lower limb power despite differences in lower limb strength, suggesting the differences in 1RM leg press above may be due to procedural differences. Upper body power was measured using a medicine ball throw, and experienced high variety in results, ranging from 31.90 cm (48) to 678.90 cm (43). The result of 31.90 cm appears to be an extreme outlier, and the reason why is unknown, as the procedure used in that study (48) was similar to the study that produced the result of 678.90 cm (43), the only difference being the weight of the ball.

Peak power was calculated using a variety of methods, impacting direct comparison. In the study by Dhahbi et al. (16) lower peak power (251.13 W) was found compared to the SWAT officers (5531.63 W) (12) and the U.S. Army Rangers (3972.00 W) (34),likely because power was calculated using an upper body test in the study by Dhahbi et al (16), instead of a vertical jump (12, 34). SWAT officers demonstrated the highest peak power when compared to the U.S. Army Rangers and could be attributable to the difference in equations used (12, 34). Upper body power tests may be useful in military special forces, due to their requirement to bear their body mass with, and attached loads to, their upper limbs. This ability may not be seen commonly in specialist police forces (17).

ETUs, on average produced a vertical jump (mean of means=49.60 ± 6.41cm (12, 25, 34, 38, 43)) higher than the general population (30 cm (9)) and general military (44 cm (24)), and on a similar level to general police depending on age (40.34 cm to 58.47 cm (14)).

Muscular Endurance: Muscular endurance was also recorded in a variety of ways and included pull ups, sit ups, back extensor holds and more. Maximum pull ups were performed in both specialist police and elite military populations and performance was similar across both (11, 45). This is confirmed by performance in two-minute push up and two-minute sit up tests (11, 48). There were also a variety of measures that did not include push ups or sit ups, such as bent hangs, knee bends, and bends with bar, however these papers failed to describe a reason for why these measures had been chosen and recorded (25, 31). When comparing similar tests, ETUs demonstrated higher muscular endurance in push ups and sit ups compared to the general population (push up: 4 to 41 repetitions; sit up: 13 to 75 repetitions (3)), general police population (push up: 39.20 to 46.52 repetitions; sit ups 25.40 to 40.98 repetitions (14), and general military (push up: 60.2 repetitions; sit up: 70.5 repetitions (50)).

Flexibility: The only measure of flexibility similar across multiple studies was the sit and reach test (25, 38, 48). This measure experienced a high range of variation (range of means= 13.57 cm (48) – 75.00 cm (38)) (25, 38, 48). However, these studies failed to describe their procedure in enough detail (38, 48), o allow comparison. Given these limitations, those in a specialist policing population appeared to perform better on the sit and reach (38). In the male general population, sit and reach test scores ranged from 12.70 cm to 55.88 cm depending on age (14), while in general police these scores have been reported as 45.00 cm (47). In a general military population, Heinrich et al. (24) reported findings of 27.60 cm. The results reported in the general population and general military are lower than the mean of means in the studies (mean of means=39.92 ± 31.63 cm (25, 38, 48), found by this review, while the general police recorded a higher result than the ETUs.

Aerobic Fitness: In a similar manner to many of the other assessments, aerobic fitness measures varied greatly in testing procedures. $VO_{2\ Max}$, both relative and absolute, were the only similar measures across all studies. From these results it was found that those in military special forces have a higher $VO2_{Max}$ (33, 43-46) when compared to a specialist police force (38), though only one specialist police force reported VO_2 scores. The results in this study do however show that elite tactical populations have a greater relative $VO_{2\,max}$ when compared to the general population (42.4 to 44.5 ml/kg/min(53)), general police force (37.50 ml/min/kg to 44.90 ml/min/kg (14)) and general military personnel (47.80 ml/min/kg (41)) depending on age.

Agility and Speed: Lastly, agility and speed did not have any similar measures across the various studies, making comparisons between populations difficult. With the exception of one study, who based their agility measure off validation in sports (45), no studies reported reasoning behind their choice of tests. In a general population, sprint speeds for 5m, 10m, and 20m were found to be 1.11s, 1.92s, and 3.33s respectively (9), demonstrating a similar speed in elite tactical units as found in this review (5m=1.17s (12), 10m=1.94s (12), 20m=3.50s (12, 48)). It is important to note that the general population measured consisted of participants of noncompetitive sports team with an average age of 23.90 years (9), which may explain the similar sprint times. When comparing agility, general military was found to have a time of 5.70s in a 5-10-5 shuttle test (24), which is slower than the time reported in an ETU population (5.20s (45)).

Summation: Elite tactical populations have higher fitness measures across almost all domains, except for sprint speed, power, and muscular strength. This can be intuitively understood given the higher occupational task demands elite tactical units undergo (38). Further, the results support the supposition that ETUs will require high levels of fitness and continued fitness training to be able to perform their occupational requirements (36, 42). While there were areas where general tactical populations had similar, or even higher measurements, i.e. sprint speed, power, and muscular strength, these results need to be considered with caution given the variability in testing protocols, as well as the limited ETU data. With more research and more comparable measures, a more informed relationship can be drawn between fitness in ETUs and the general population, general military forces and general police forces.

A wide variety of measures were used throughout these papers, making direct comparison difficult. Moving forward, research should investigate specific measures and how they correlate to injury risk or task performance or utilize tests that have already been previously validated in the literature. For example, the 20m Progressive Shuttle Run has been validated as a way to establish aerobic fitness (29), and been linked to injury risk in military (37). Upper body strength measures such as a one repetition max pull up and bench press may also be recommended as they are highly correlated with loaded march performance (42), an important requirement for specialist personnel (46). It could be that certain tests will be better suited for certain groups, however with More research on various measures and their impact on various tactical groups will allow ETUs to choose which measures make up their specific profiles and meet their specific needs. If other measures are chosen, researchers should explain the thought process and reasoning behind their selection to better allow for an understanding of why variations in measures occur.

The three key fitness measures that should make up any profile are aerobic fitness, muscle endurance, and muscle strength, as seen by their impact on task performance and injury risk (36, 42). However, the ways these are measured needs to be further researched and analyzed so the highest quality and most task-specific measures can be used to assist ETUs in returning their members to active duty from injury. These fitness profiles can also lead to the development of specific strength and conditioning programs that are focused on improving task and field performance and ultimately this can allow ETUs to continue to be the forefront of national security, and to perform above and beyond what is expected of the general tactical population.

Limitations: The first limitation in this review is the potential for language bias. As only English words were used for search terms, combined with the fact that only English databases were searched, there is potential for missed studies written in another language. Another limitation was the disparity between included populations. Only three studies included police populations, while no specialist firefighter populations were identified. On this basis, the transferability of these findings to specialist policing is limited and to other specialist tactical units, like those in Fire and Rescue, must be made with caution.

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