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ASSESSMENT OF PHYSICAL FITNESS IN MILITARY AND SECURITY FORCES: A SYSTEMATIC REVIEW

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ABSTRACT

The aim of this systematic review was to comprehensively study the physical fitness test and batteries used by military and security forces. Our ultimate goal was to propose a physical fitness test battery to be used in military and security forces based on the currently available evidence. A literature search was conducted using four electronic databases; MEDLINE, SCOPUS, SPORTDISCUS and PUBMED and two search platform; OVID and EBSCOhot. Four categories of search terms were identified: assessment, tool, fitness and organization. Titles and abstracts were reviewed to determine whether the studies met the inclusion criteria. The electronic search strategy produced 5,492 studies. After applying the inclusion criteria, we identified a total of 193 studies. One hundred fifty-six studies (80.83%) assessed cardiorespiratory fitness, 133 studies (68.91%) assessed muscle skeletal fitness, 16 studies (8.29%) assessed motor fitness and 124 studies (64.25%) assessed body composition. The test that has been used the most included the 2.4 km run, sit-ups and pull-ups tests as well as body mass index, percentage of body fat measured by skinfold thickness and body weight and fat free mass. Meanwhile more evidence is accumulated in military and security forces, these tests should be included when assessing physical fitness in this population setting.
Key Words: physical fitness, military, security forces, health

RESUMEN

El objetivo de esta revisión sistemática fue estudiar exhaustivamente los test y baterías de condición física utilizadas por las fuerzas militares y de seguridad. Nuestro objetivo final es proponer una batería de test de condición física para ser utilizado en las fuerzas militares y de seguridad sobre la base de la evidencia disponible en la actualidad. Se realizó una búsqueda bibliográfica utilizando cuatro bases de datos electrónicas; MEDLINE, SCOPUS, SPORTDiscus y PUBMED y dos plataformas de búsqueda; OVID y EBSCOhot. Se identificaron cuatro categorías de términos de búsqueda: evaluación, herramienta, condición física y organización. Los títulos y los resúmenes fueron revisados para determinar si los estudios cumplían los criterios de inclusión. La estrategia de búsqueda electrónica produjo 5.492 estudios. Después de aplicar los criterios de inclusión, se identificaron un total de 193 estudios. Ciento cincuenta y seis estudios (80,83%) evaluaron la capacidad cardiorrespiratoria, 133 estudios (68,91%) evalúan la capacidad física musculo-esquelética, 16 estudios (8,29%) evalúan la capacidad motora y 124 estudios (64,25%) evaluaron la composición corporal. Los test más utilizados son los 2,4 km de carrera, flexión de tronco y flexión de brazos, así como el índice de masa corporal, porcentaje de grasa corporal medida por el espesor del pliegue cutáneo, el peso corporal y la masa libre de grasa. Mientras más evidencia se acumula en las fuerzas militares y de seguridad, estas pruebas deberán incluirse en la evaluación de la condición física en este ámbito poblacional.
Palabras clave: entrenamiento físico, militar, fuerzas de seguridad, salud

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INTRODUCTION

Physical fitness is an important marker of health (Erikssen, 2001). Military and security forces need to have a relatively high level of physical fitness due to the high physical activity demands during military training and in warfare (J. Knapik et al., 1990). Monitoring the physical fitness level of the military and security forces is important from a performance point of view, as well as to assess their combat ability.

The change from civilian routine to the physically demanding military routine led to significant improvements in body composition, postural control, trunk muscle fitness, aerobic fitness and total physical fitness (Hofstetter, Mader, & Wyss, 2012; Mikkola et al., 2012). A low physical fitness among recruits, is likely to affect the military training as well as fulfilment of military duties (Tomczak, Bertrandt, & Kłos, 2012). To find an optimal balance between physical fitness and job requirements is important to military members due to the increased physical demands in military training and in warfare (J. Knapik et al., 1990). Physical fitness may protect soldiers against combat stress symptoms even during deployment, and its effects may be mediated by (i) fitness-related attenuations stress (Rintamäki et al., 2012; Taylor et al., 2008) and (ii) reduction of the risk of injuries (Bedno, Cowan, Urban, & Niebuhr, 2012). Intensive exercise training is known to improve cardiovascular disease risk factor levels, lead to weight loss and visceral fat area (Cederberg et al., 2011) and increases of cardiorespiratory fitness. This seems to translate into a lower rate of long-term mortality and a higher levels of health related quality of life (Aslani, Kheirkhah, & Sobhani, 2011; Sloan, Sawada, Martin, Church, & Blair, 2009).

Security forces need be able to maintain a high physical fitness level to pass their job task even during the deployment (Del Sal et al., 2009; Rintamäki et al., 2012), although some studies showed that deployed units could lead to a decrease on physical fitness level (i.e. aerobic capacity, upper body power, body composition) (M. A. Sharp et al., 2008; Tomczak et al., 2012). Muscular strength has an important role when wearing heavy combat gear and performing military tasks (J. Knapik, Harman, Steelman, & Graham, 2012) and cardiorespiratory fitness can influence the ability to sustain the training load (B. Jones & Knapik, 1999). A relatively large number of studies have measured physical fitness in military and security forces setting, and as a result, numerous field-based fitness test batteries have been developed to assess fitness in this population.

The aim of this systematic review was to comprehensively study the physical fitness test and batteries used by military and security forces. Our

ultimate goal was to propose a physical fitness test battery to be used in military and security forces based on the currently available evidence.

METHOD

Search strategy

A literature search was conducted using four electronic databases; MEDLINE, SCOPUS, SPORTDISCUS and PUBMED and two search platform; OVID and EBSCOhot. Four categories of search terms were identified: assessment, tool, fitness and organization. Specific terms used in the search were obtained from the librarians´ and researchers´ expertise, and then adapted for each database (see additional file 1 for more detail). The electronic searching strategy was: [*(assess* OR measure*)* AND *(test* OR *battery*) AND (*Fitness OR strength* OR cardiorespiratory OR aerobic capacity* OR *cardiovascular* OR *muscular* OR *musculoskeletal* OR *endurance* OR *power* OR *flexibility* OR *motor* OR *speed* OR *agility* OR *coordination* OR *balance OR body composition OR weight OR height OR waist circumference*) *AND (firefigther* OR fireman* OR fireguard* OR police OR soldier* OR army OR military OR civil defence OR civil guard OR NAVY OR armed ground force* OR *air force* OR *naval forces* OR *gendarmerie* OR *national guard* OR *marine* OR *royal guards)*]. All publications through February 2013 were included.

Selection and review process

Once the list of potentially relevant studies was compiled, titles and abstracts were reviewed to determine if the studies met the following inclusion criteria: a) measured fitness with a test or battery; b) focus on military forces or other organized forces (fireman, police, etc.); c) belong to a peer-reviewed journal. Any disagreements in the inclusion process were resolved through discussion among authors. Data were then extracted from the studies including: fitness component (cardiorespiratory fitness, muscular endurance, muscular power, strength, anaerobic performance, flexibility, agility, speed, coordination, balance, effort perception, body composition) general characteristics of the study (i.e. authors, country and locality, sample size, gender, age and organization) and specific characteristics of the fitness test or battery (fitness test or battery, variables).

RESULTS

Study selection

The electronic search strategy produced 5,492 studies from de 4 databases and 2 search platform: 1,494 from MEDLINE (in PROQUEST), 13 from SCOPUS, 309 from SPORT DISCUS, 2,139 from PUBMED, 45 from OVID and 1,492 from

EBSCOhot. After discarding duplicates 3,798 studies remained. From 3,798 studies, 193 were selected because they accomplished the inclusion criteria based on a review of titles and abstracts. After carefully reading the full text, the final numbers of studies included in the current review were 193 studies.

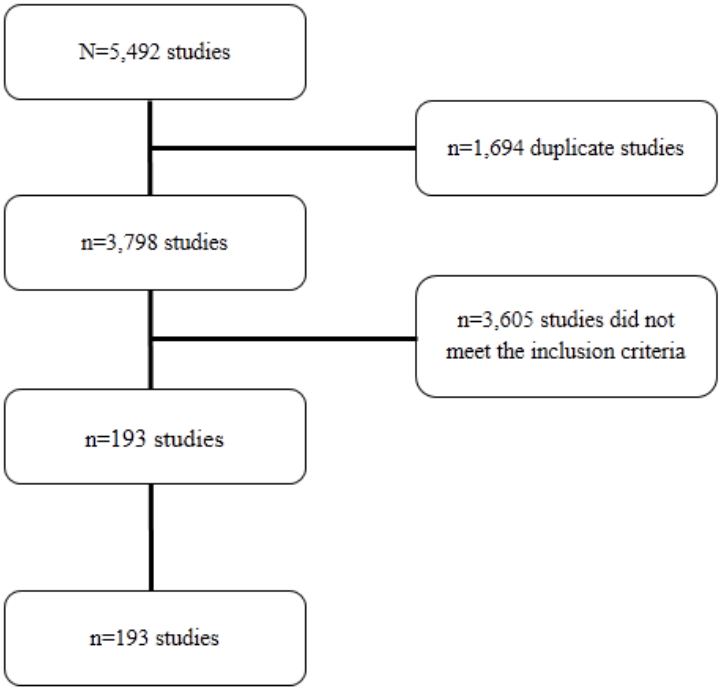

FIGURE 1: Flowchart of the research reviewed

Study population

The characteristics of the studies identified are shown in Table 1. The studies were carried out in the United States (n=85, 44.04% studies), Finland (n=13, 6.74% studies), United Kingdom (n=12, 6.22% studies), Israel, Norway, and Sweden (n=6, 3.12% studies in each country), Brazil (n=5, 2.59% studies), Canada (n=4, 2.07% studies), France, Australia, Germany and Slovenia (n=3, 1.55% studies in each country), Afghanistan, Croatia, Switzerland, Denmark, Spain and Netherland (n=2, 1.04% studies in each country) and Taiwan, Poland, Malaysia, Lithuania, Hungary, Singapore, Greenland, Italy, Cyprus and Ireland (n=1, 0.52% studies in each country). Therefore, there were studied conducted in four continents: Europe, America, Asia and Oceania. One of the studies was

conducted in Norway and Kosovo (multicentre studies) (n=1, 0.52% studies). A total of 21 studies did not report the country (10.88% studies).

A total of 36 different forces were analysed: recruits (n=43, 22.28% studies), soldiers (n=22, 11.40% studies), Army (n= 21, 10.88% studies), conscript (n=14, 7.25% studies), Air Force and police (n= 13, 6.74% studies each force), cadets (n=12, 6.28% studies), NAVY (n=11, 5.70% studies each force), infantry, active duty and fire-fighters (n=5, 2.59% studies each force), National Guard and military personnel (n=3, 1.55% studies each force), Marine, training corps, Special Operation, NAVY Special Operation and military physicians (n=2, 1.04% studies each force), and Veterans and defence force (n=1 0.52% studies each force). Only four studies were conducted in several forces (Artillery, ranger, soldiers, NAVY sailors, Army, Army Ranger students, Royal Air Force, Royal NAVY, NAVY and Marine).

The sample size differed from study to study, the smallest including 2 men aged 25 years (Frykman et al., 2003) and the largest involving 1,578,694 men' participants with an mean age of 18.3 years (Martin Neovius & Rasmussen, 2008).

Around half of the reviewed studies were conducted only with men (n= 95, 49.22%) and in both men and women (n= 79, 40.93%). Few studies were conducted in women (n= 8, 4.15%) and 11 studies did not report this sex-related information (5.70%).

Measurement of physical fitness components

Four fitness components were identified. Cardiorespiratory fitness was the most common fitness component measured (n=156, 80.83% studies). Other fitness components included muscle skeletal fitness (n=133, 68.91%), motor fitness (n=16, 8.29%), and body composition (n=124, 64.25% studies). In addition, one study reported the rating of perceived exertion (the so called RPE).

Assessment of fitness tests and test batteries

More than half of the reviewed studies used a combination of tests (n=118, 61.14% studies) while a total of 25 studies used batteries of tests (12.95% studies). A total of 50 studies used both tests and batteries (25.91% studies).

The Army Physical Fitness Test was the most used fitness test battery (n=31, 16.06%) followed by the Physical Readiness Test battery (n=6, 3.11%). Four studies used the Assessment of Recruit Motivation and Strength battery (2.07%) and three studies used the Air Force Physical Fitness Test battery (1.74%). Four different batteries were used in 2 studies (1.04% each battery) and 33 fitness test batteries were used once (0.58% each battery). Eight studies

(4.15%) applied the Physical Fitness Test battery although the tests included in the battery were different.

Cardiorespiratory fitness was measured by the incremental treadmill run test (n=30, 15.54%), the 2.4 km run test (n=18, 9.33%), the incremental exercise on cycle ergometer test and the 12 minute run (n=13, 6.74% each test) , 20 m shuttle run test, Wingate cycle-ergometer test and 3.2 km run (n=8, 4.15%) tests. Other 39 tests were identified with a percentage of 2.07 or fewer.

Muscle skeletal fitness was measured by sit-ups (n=28, 14.51%), push-ups (n=23, 11.91%), hand grip strength (n=19, 9.85%), pull-ups (n=13, 6.74%), vertical jump (n=11, 5.70%), bench press (n=9, 4.66%), standing long jump (n=9, 4.66%), leg extension (n=7, 3.63%) and sit and reach tests (n=7, 3.63%). Other 71 tests were identified with a percentage of 3.10 or fewer.

Motor fitness was measured by means of 7 different tests for agility (n=1, 0.52% each test), 7 different tests for speed (n=2, 1.04% one test and n=1, 0.52% six test), 3 different tests for coordination (n= 2, 1.04% two test and n=1, 0.52% one test) and 3 different tests for balance (n=1, 0.52% each test).

Body composition was measured by means of body mass index (n=87, 45.08%), percentage of body fat (n=66, 34.20%), weight (n=51, 26.43%) and fat free mass (n=24, 12.44%). Percentage of body fat was commonly measured by skinfold thickness, of which triceps, subscapular, suprailiac and biceps were the most commonly measured.

Finally, the variables most used were: body mass index (n=87, 45.08%), percentage of body fat (n=66, 34.20%), $VO_{2\,max}$ (n=57, 29.53%), weight (n=51, 26.43%), heart rate (n=32, 16.58%) and fat free mas (n=24, 12.44%).

DISCUSSION

The current study aimed to systematically review the studies that measured physical fitness in military and security forces setting. The present systematic review shows that there are several batteries and test to conduct the measurement of physical fitness in military and security forces. The most common fitness test batteries are those that include the measurement of cardiorespiratory fitness, muscle skeletal fitness and body composition. The battery Army Physical Fitness is the most common, and the incremental treadmill run together with the 2.4 km run, the sit-ups and push-ups test are the most commonly used tests in the literature. Additionally, body composition is usually assessed with body mass index, percentage of body fat and fat free mas.

Cardiorespiratory fitness is an important component of the training program, which is known to be associated with the prevention of chronic diseases (B. Jones & Knapik, 1999; Myers et al., 2002). Most of the fitness test

batteries analized (i.e. Army Physical Fitness Tests, Physical Readiness Test, Assessment of Recruit Motivation and Strength, etc.) include at least one test assessing cardiorespiratory fitness. To assess cardiorespiratory fitness, maximal oxygen consumption (VO_{2max}) is the most widespread outcome. Maximal exercise test like the 12 minute run and 20 m shuttle run test have shown a correlation coefficient of 0.92 and 0.86 relative to the treadmill VO_{2max} (Grant, Corbett, Amjad, Wilson, & Aitchison, 1995). However, the 12-minute run or distance running test (i.e. 2.4 km run or 3.2 km run) have been shown difficulties to find the optimal speed in inexperienced runners (JØrgensen et al., 2009). Other observed difference across the tests is the equipment required to carry on. Incremental treadmill run or Wingate cycle-ergometer test needs specific equipment, which is used individually or by small groups of participants. This problem is solved in the 12 minute run, or in the 20 m shuttle run test or distance test. Therefore, the decision to select a test is influenced by the available equipment and by the number of participants who can perform the test simultaneously.

Muscle skeletal fitness has been related to performance ability in military task (A. G. Williams, 2005). It seems to be one the best predictors for carrying out operational demand of military forces (Simpson, Gray, & Florida-James, 2006). We found a relatively large number of tests assessing muscular endurance (i.e. sit-ups, push ups, etc.), maximum strength (i.e. hand grip strength, vertical jump, etc.) and flexibility (i.e. sit and reach). The fitness test batteries reviewed (e.g. Army Physical Fitness Test, Physical Readiness Test, etc.) include tests to assess muscular endurance and muscular strength. A major problem when assessing muscle skeletal fitness is that there are no a proper standardization of the tests. For example, there are different versions of sit-ups (i.e. number of sit-ups during one minute, number of sit-ups during two minutes or number of sit-ups until exhaustion, etc.), which hamper comparison among studies. It is worth mentioning that most of the test found in this review assessing muscle skeletal fitness focused on upper body extremities or trunk. It has been showed that upper body strength seems to have more impact on military tasks and routinely perform manual material handling tasks (Pandorf et al., 2003; Pori, Tušak, & Pori, 2010). However, lower body extremity assessment is important for military or security forces due to the importance while performing combat duties (Lester et al., 2010; Pori et al., 2010). Despite flexibility seems to be an important muscle skeletal fitness component (Garber et al., 2011), stretching exercises could prevent injuries and improving performance (Rubini, Costa, & Gomes, 2007), this dimension is not frequently measured in military and security settings.

We observed that motor fitness is the less common fitness component, only assessed by 16 studies (8.29%). Due to the low number of studies assessing motor fitness and the use of different test made incomparable the results between studies. Working efficiency is related with some motor fitness test (coordination and speed test mainly) because shows the ability of efficient resolution of space-related problems and a quick reaction in daily task (Pori et al., 2010). This component is the least used by researchers, yet on the modern battlefield soldiers should successfully overcome obstacles in order to complete the combat mission (Pandorf et al., 2003). In addition, the assessment of motor fitness components could be a predictor of the appearance of injuries. Some studies suggest that balance and agility training are effective reducing injuries in sports (Myklebust et al., 2003; Olsen, Myklebust, Engebretsen, Holme, & Bahr, 2005).

Body composition assessment is widespread on the literature reviewed. Common ways to assess body composition include body mass index, percentage of body fat, weight and fat free mas. The prevalence of overweight and obesity is relatively common in military and security forces population (Bathalon et al., 2006; Mikkola et al., 2012), which might affects the ability to train (Tanskanen et al., 2009). The importance to assess this component lies in health and economic issues. Previous studies suggest that overweight and obese military personnel had an increased risk of sick-leave, especially for sick-leave episodes of long duration, and obesity is associated with high productivity losses, producing a high cost (K. Neovius, Neovius, Kark, & Rasmussen, 2012; K. Neovius, Rehnberg, Rasmussen, & Neovius, 2012; M. Neovius, Kark, & Rasmussen, 2008). Additionally, changes in body composition might change the capacity of military personnel in other fitness component and military tasks. Reducing body fat is associated with an improvement on cardiorespiratory fitness (Mattila, Tallroth, Marttinen, & Pihlajamäki, 2007; Mikkola et al., 2012). Regarding military tasks, deployment negatively affected aerobic capacity, upper body power and body composition (M. A. Sharp et al., 2008). Therefore, even when the duties are deployed, body composition is as important as the other components.

Strength and limitations

To our knowledge this is the first systematic review of physical fitness assessment on military and security forces. The large number of studies included in our review (n=193) allowed us to draw firm conclusions, which resulted in the recommendation for a standard assessment of physical fitness in military and security forces. In contrast, we may still have missed some

relevant evidence due to poor indexing in some databases or indexing in databases not selected for the review process.

CONCLUSIONS

According to the current systematic review, to conduct a complete assessment of the most important fitness components (cardiorespiratory fitness, muscle skeletal fitness and body composition), we propose a physical fitness test battery based on the low level of required material and the widespread utilization on military and security forces. The fitness test battery should include: the 2.4 km run, sit-ups and pull-ups tests as well as body mass index, percentage of body fat measured by skinfold thickness, body weight and fat free mass. Meanwhile more evidence is accumulated in military and security forces, these tests should be included when assessing physical fitness in this population setting.

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