Fitness levels of rural emergency medical and rescue service providers in the North West province, South Africa

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ABSTRACT

Background: Studies investigating the physical fitness levels of emergency care providers (ECPs) in relation to their occupational demands in South Africa are limited, despite the importance of physical fitness for the occupation. There are no fitness guidelines available, nor are periodic fitness assessments of ECPs performed in the workplace.

Objective: The objective of the study was to measure the physical fitness of ECPs in the North West province of South Africa, using a validated motor fitness test battery.

Methods: Ninety-one volunteers completed nine field tests (fitness, sit-and-reach, push-ups, sit-ups, flexed-arm hang, hand grip-strength, isometric leg and torso lift, 250 m shuttle run, and a 12-minute run/walk). Anthropometric measurements were recorded. The Student's t-test was used to determine any significant differences in test scores between male and female ECPs.

Results: Sixty-four male and 27 female ECPs participated in the study. The mean ages of the male and female ECPs were 36.5 years and 37.0 years, respectively. There was a high prevalence of overweight/obesity, as defined by body mass index, for both male (71.9%) and female (77.7%) ECPs. Male ECPs demonstrated superior muscular strength, muscular endurance, and aerobic and anaerobic capacity, compared to female ECPs. Most participants had poor aerobic capacity (62.7%), grip-strength (57.1%), lower body strength (95.6%) and muscular endurance measured by the push-up test (32.9%), one-minute sit-up test (67.0%) and flexed-arm hang test (53.8%).

Conclusion: Many of the ECP study participants were not physically fit for duty. Measured fitness levels indicate that they may not be able to perform their occupational duties to the level required. The job requires much physical effort, and poor fitness may result in personal injury and risk patients' lives. The ECPs would benefit from exercise training to improve fitness and lower the risk of musculoskeletal injuries.

INTRODUCTION

Emergency medical care (EMC) is defined as the rescue, evaluation, treatment and care of an ill or injured person in an emergency, and the continuation of treatment and care during transportation of that person to, or between, health establishments.[1] Emergency care providers (ECPs) are required to rescue such persons as rapidly and efficiently as possible,[2] which places high mental and physical demands on the ECP.[3]

High levels of physical fitness among ECPs are necessary in order to perform strenuous duties effectively and to reduce the risk of injury to themselves, their colleagues, and their patients.[4] The profession is characterised by sudden quick transitions from periods of inactivity to vigorous activity when responding to emergency incidents, which requires a high level of physical fitness.[3] Russo et al. (2011)[5] found that healthcare professionals with high physical fitness levels were able to perform higher-quality chest compressions during cardiopulmonary resuscitation (CPR), and demonstrated a lower incidence of rescuer fatigue, compared to those with lower physical fitness levels. This may be related to greater strength and endurance capacity of the physically fit healthcare providers.

Chapman et al. (2007)[4] showed that Western Australian male paramedics who had adequate levels of aerobic capacity, local muscular strength and endurance also had adequate levels of workplace competence. By implication, fit paramedics should be able to work longer, harder and more efficiently than unfit service providers. Conversely, Hunter et al. (2018) recently found that a cohort of 139 paramedics in New South Wales, Australia, had insufficient core and lower body strength as well as poor flexibility, predisposing them to increased risk of work-related musculoskeletal injuries when performing demanding manual handling tasks. High body fat and pre-hypertensive blood pressure levels further suggested an increased risk of cardiometabolic disease in this group.[6] A similar study conducted in Australia found that increased age of paramedics was correlated with poorer upper and lower body strength, core strength, and flexibility in a cohort of regional paramedics.[7] A review of the literature by Sheridan (2019) showed that excess weight was common among paramedics, putting them at risk of cardiovascular disease.[8]

Studies investigating the physical fitness profiles of ECPs in relation to their occupational demands in South Africa are limited, despite the importance of physical fitness for the occupation. There are no fitness guidelines available for this group of workers, and periodic fitness assessments of ECPs are not performed in the workplace. Although there are fitness normative data (norms) for the general population, there are none that are specific to ECPs.

The ECPs in South Africa not only work in an ambulance setting, but also perform rescue operations in conjunction with other rescue organisations. Therefore, they are expected to demonstrate fitness levels above those of the general population.

The objective of this study was to determine the physical fitness levels of ECPs working in a rural area in South Africa, using a validated motor fitness test battery.[9]

METHODS

This was a cross-sectional study. There were approximately 600 ECPs working in 32 emergency stations in the four districts of North West province, South Africa, at the time of the study. The study population comprised ECPs aged 25 to 50 years with two or more years of work experience, and registered with the Health Professions Council of South Africa (HPCSA). Those who had a musculoskeletal injury or a disability, were pregnant, or were on temporary suspension from work were excluded from the study. The study population comprised 230 ECPs who were basic ambulance assistants, ambulance emergency assistants, emergency care assistants, critical care assistants, emergency care technicians and emergency care providers as recognised by the Professional Board of Emergency Care of the HPCSA.[10] Potential participants were recruited from the North West Department of Health employer database, via e-mail.

Tests were conducted in a standardised fashion, based on the American College of Sports Medicine (ACSM) criteria.[11] All participants were asked to have a light breakfast on the morning of testing and to wear comfortable shorts and t-shirts. They were also asked not to exercise for 48 hours prior to the testing. All tests were administered by a qualified biokineticist and trained sports scientists. Participants were tested in groups of 20, and the testing was completed over a 10-day period. The tests were conducted at a single testing station at the same time of day.

The participants completed questionnaires from which information regarding age and sex was collected. Height and body mass were measured, using a Micro A12 physician scale (Premier Scale Services) with a vertical ruler. Body mass index (BMI) was calculated as body mass (kg)/height squared (m^2).

The fitness test battery comprised nine field tests that measured muscular strength (MS), muscular endurance (ME), cardiorespiratory fitness (aerobic and anaerobic), and flexibility. Height, weight and flexibility were measured consecutively, at different stations. Participants rested for 10 minutes between each of the remaining tests, as recommended by the ACSM.[11] Scores were based on sex-specific norms.

The modified sit-and-reach (MSR) test was used to measure flexibility of the lower back and hamstrings.[12] A wooden 30 cm x 30 cm sit-and-reach box with a sliding scale and a 30 cm ruler were used to measure the distance between the box and the tip of the fingers.[13] Participants attempted three trials; the result of the best trial for each person was recorded.

The maximum push-up test (performed in one minute) was used to determine the upper-body ME of participants.[14] Women performed a modified push-up test (with knees on the ground). Upper body ME was classified as 'good', 'average' or 'poor' in the maximum push-up test, in accordance with the US general population norms defined by Howley and Thompson (2016).[14] A one-minute sit-up test measured abdominal ME. The number of sit-ups performed in one minute was recorded.

The flexed-arm hang test (FAHT) measured upper-body ME which is correlated with upper-body strength.[9,15] A wall-mounted pull-up bar (Matrix Fitness SA) was used. The participants were required to hang on the bar for as long as possible, using an under-grip technique, with elbows flexed at 90 degrees. The best performance out of three trials was recorded, i.e. the longest time (in seconds) that participants could hang onto the bar with their chins above it.

A hand grip-strength test, using a Saehan Medical (Saehan Corporation) hydraulic hand grip dynamometer, measured the maximum amount of force (kg) generated during a hand grip of three seconds.[16] Three trials were performed on each hand and the highest measurement in one hand was added to that of the other. The mean of the measurements for both hands was recorded.

Isometric leg and torso lift tests, using a Saehan SH5007 (Saehan Corporation) back-chest-leg dynamometer, measured the maximum amount of isometric force (kg) generated by the lower body as well as the lower back musculature of participants, within three seconds.[16]

A 250 m shuttle run test indirectly measured the anaerobic capacity of participants. Two agility cones, 10 m apart, and a stop watch were used as apparatus.[17] The participants were considered to have adequate anaerobic capacity if they achieved an 'average' or 'good' rating for this test based on the normative values developed by Coopoo and Govender (2002)[17] for South African rugby players, in the absence of adult normative values for the general population.

The Cooper 12-minute run/walk test[14] evaluated the aerobic capacity of participants. A distance measuring wheel, four agility cones and a stop watch were used. The distance covered in metres was used to estimate the VO_2 max, using the following equation:

$$VO_2 = \text{horizontal velocity (m·min-1)} \cdot x = \frac{\text{0.2 ml ·kg-1 ·min-1}}{\text{(m·min-1)}} + \text{3.5ml} \cdot \text{kg -1·min}^{-1}$$ [14]

A participant's VO_2 max was rated as 'inadequate' if it was 'below average' or 'poor' in accordance with the US general population norms defined by Howley and Thompson (2016).[14]

Ethics approval for the study was obtained from the Research Ethics Committee of the Faculty of Health Sciences, University of

Table 1. Demographic characteristics of study participants (N = 91)

	Males (n = 64)			Females (n = 27)			
Characteristic	Mean	SD	Range	Mean	SD	Range	p value
Age (years)	36.5	5.5	26.0–50.0	37.0	5.4	26–48	0.545
Height (cm)	170.5	6.2	156.0–187.5	160.0	5.6	149–176	0.001
Weight (kg)	80.9	13.9	54.7–119.7	76.1	17.2	46.6–111.3	0.312
BMI (kg/m^2)	27.8	4.7	17.7–38.4	29.0	5.4	18.0–37.5	0.201

Johannesburg (REC-01-159-2016). Permission was also granted by the North West Department of Health to conduct the study on their employees.

DATA ANALYSIS

All data were captured on a Microsoft Excel spreadsheet. Scores were based on the US adult norms developed/set by Howley and Thompson (2016)14 and those developed by Coburn and Malek (2012).[18] The software package, SPSS version 25 (IBM), was used for the statistical analysis. Differences were described by sex, age and BMI. The Student's t-test was used to compare variable means. The level of significance was set at 95%.

RESULTS

Although 120 of the 230 identified ECPs (52.2%) agreed to participate in the study, only 91 (39.6%) completed the tests. As shown in Table 1, most of the study participants were male (n = 64; 70.3%). The mean ages of men and women were similar (36.5 and 37.0 years, respectively; p = 0.545); overall, ages ranged from 26 to 50 years. Men were taller, on average, than women (170.5 and 160.0 cm, respectively; p = 0.001) and heavier (80.9 and 76.1 kg, respectively; p = 0.312). Weights ranged from 46.6 to 119.7 kg. However, female participants had higher mean BMIs than male participants (29.0 and 27.8 kg/m^2, respectively; p = 0.201). There was a high prevalence of overweight/obesity in both male (71.9%) and female participants (77.7%), as shown in Table 2.

Table 2. BMI classifications of participants (N = 91)

	Males (n = 64)		Females (n = 27)	
BMI	n	%	n	%
Underweight (< 18.5 kg/m^2)	0	-	1	3.7
Normal (18.5–24.9 kg/m^2)	18	28.1	5	18.5
Overweight (25.0–29.9 kg/m^2)	24	37.5	9	33.3
Obese (> 30 kg/m^2)	22	34.4	12	44.4

Male participants performed significantly better than female participants in the muscular endurance, muscular strength, and aerobic and anaerobic capacity tests (Table 3). Although female participants were more flexible than male particpants, the difference was not statistically significantly.

The scoring of the participants' abilities in the fitness test battery are presented in Table 4. Female participants performed best in the MSR test (n = 15; 55.5% showed 'good' performance), followed by the isometric torso test where the performance of 48.1% (n = 13) was rated at 'good', and the grip-strength test (n = 11; 40.7%). Male participants provided their best performances in the 250 m shuttle-run test (n = 45; 70.3% were rated as 'good'), followed by the push-up test (n = 50; 56.3%) and the MSR test (n = 32; 50.0%). A higher proportion of female than male participants had a good rating in the grip-strength test (20.7% and 12.5%, respectively), while male participants outperformed female participants in the 250 m shuttle-run test (70.3% and 11.1% of male and female participants were rated as good, respectively), and the maximum push-up test (good ratings were observed for 56.3% and 29.6% of male and female participants, respectively).

The overall poorest performance was for the isometric leg-lift test with 95.6% of the participants scoring 'poor', followed by the one-minute sit-up test (67.0% were rated as poor), and Cooper 12-minute run test (62.7% were rated as poor). All male (100%) and most female participants (85.1%) performed poorly in the isometric leg-lift test, and most participants of both sexes performed poorly in the one-minute sit-up test (64.0% and 74.0% of male and female participants, respectively) and the Cooper 12-minute test (53.1% and 85.1% of male and female participants, respectively).

DISCUSSION

Body mass index

Many of the participants in this study were overweight or obese. Similarly, Tsismenakis et al. (2009) reported that 43.8% of cohort members were overweight and 33% were obese in a study of 160 Australian paramedics/emergency care technicians and

Table 3. Fitness test results for male and female ECPs (N = 91)

	Males (n = 64)		Females (n = 27)		p value
Fitness test category	Mean	SD	Mean	SD	
Muscular endurance					
Maximum push-up (no.)	26	12	8	9	< 0.001
One-minute sit-up (no.)	29	9	17	11	< 0.001
Flexed-arm hang test (sec.)	34.5	16.0	9.4	11.3	< 0.001
Muscular strength					
Isometric leg lift (kg)	117.8	24.7	77.6	21.0	< 0.001
Isometric torso lift (kg)	113.1	21.9	72.4	17.7	< 0.001
Grip strength (kg)	43.6	7.5	31.2	5.5	< 0.001
Flexibility					
Modified sit-and-reach (cm)	34.3	8.1	37.9	7.2	0.098
Aerobic capacity					
Cooper 12-minute run (m)	1960.3	395.5	1538.1	293.7	< 0.001
Predicted VO_2 max (ml.kg.min^{-1})	32.5	8.9	23.1	6.6	< 0.001
A***naerobic capacity***					
250 m shuttle run (sec.)	67	7	89	15	< 0.001

270 firefighter candidates.[19] Overweight and obesity in the work environment are associated with musculoskeletal disorders and injuries, asthma, immune responses, cardiovascular disease and certain cancers.[20]

Studies have shown that there is a direct relationship between BMI and fitness levels. For example, Priya and Chetan (2019) investigated a relationship between BMI and physical fitness in a group of adult basketball players and found that BMI was inversely correlated with muscular strength and anaerobic power, i.e. the higher the BMI, the lower the performance.[21] Nikolaidis (2013) showed that volleyball players with high BMI values and body fat were more likely to have lower scores in physical fitness.[22] Excess BMI may be the reason for lower levels of physical fitness among ECPs. Hegg-Deloye et al. (2014) identified that work-related dietary behaviour and occupational stress were associated with an increase in BMI among Canadian paramedics.[2] Stress may have contributed to the high BMIs in the group of rural EMCs in the North West province of South Africa.

MUSCULAR ENDURANCE

Although two thirds of the study participants demonstrated acceptable (good or average ratings) upper body ME, the male participants performed worse in the push-up test than those in a group of Australian paramedics[6] (26 ± 12 vs. 40 ± 12 push-ups). The authors did not indicate whether the Australian paramedics engaged in any programmes relating to physical fitness which might have explained their higher levels of ME.

Only a third of participants had acceptable abdominal ME as demonstrated in the one-minute sit-up test, according to norms set by Coburn and Malek (2012).[18] Poor abdominal ME may lead to early fatigue of the abdominal muscles during repetitive tasks and poor control of the core musculature/stability. This might lead to a number of activities being inefficiently carried out within the rescue setting. For example, the quality of compressions in CPR could be compromised, lifting of patients on to a stretcher may be ineffective as the ECP may lack the necessary strength required to complete this task, and repetitive activities could be poorly executed. This impacts directly on patient care and the delivery of patients to healthcare facilities. Fatigue and poor control of core musculature can also lead to lower back musculoskeletal injuries among ECPs during rescue activities,[23] which could potentially increase the number of sick leave days taken and impact on service delivery.

More than half of the ECPs demonstrated poor upper body ME in the FAHT, which is an important indicator for activities requiring lifting of heavy loads (e.g. rescue equipment) as well as repetitive movements (e.g. aquatic rescue). Poor upper body ME may lead to premature rescuer fatigue during repetitive tasks. Poor upper body and core strength may lead to ECPs being unable to effectively handle and use emergency equipment, such as the Jaws of Life which weigh approximately 22 kg, thereby placing both themselves and patients at risk of further injury.

MUSCULAR STRENGTH

A quarter of the study participants showed poor strength of the back extensor muscles as demonstrated in the isometric back lift test, which indirectly indicates a weak core. Weak core musculature may lead to reduced ability to generate the necessary force during lifting activities, and predispose ECPs to lower back injuries.The isometric leg lift showed that most of the participants had poor lower-body strength. Lifting activities require a strong core and lower-body musculature (such as the gluteal and other limb muscles) because they act synergistically during movements to co-contract and stiffen the torso.[18] Poor core control and weak lower-body musculature can

Table 4. Fitness ratings of participants, by sex

Test	Good						Average						Poor					
	Male		Female		All		Male		Female		All		Male		Female		All	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
250 m shuttle run (sec.)	45	70.3	3	11.1	48	52.9	19	29.7	11	40.7	30	33.0	0	-	13	48.1	13	14.2
Modified sit-and-reach (cm)	32	50.0	15	55.5	47	51.7	5	7.8	2	7.4	7	7.7	27	42.2	10	37.0	37	40.6
Maximum push-up (no.)	36	56.3	8	29.6	44	48.3	15	23.4	2	7.4	17	18.7	13	20.3	17	62.9	30	32.9
Isometric torso lift (kg)	11	17.2	13	48.1	24	26.4	36	56.3	9	33.3	45	49.5	17	26.5	5	18.5	22	24.1
Grip strength (kg)	8	12.5	11	40.7	19	20.8	17	26.6	3	11.1	20	21.9	39	60.9	13	48.1	52	57.1
One-minute sit-up (no.)	11	17.2	3	11.1	14	15.4	12	18.8	4	14.8	16	17.5	41	64.0	20	74.0	61	67.0
Flexed-arm hang test (sec.)	11	17.2	3	11.1	14	15.4	25	39.0	3	11.1	28	30.8	28	43.8	21	77.7	49	53.8
Cooper 12-minute run (m)	9	14.1	0	-	9	9.9	21	32.8	4	14.8	25	27.5	34	53.1	23	85.1	57	62.7
Isometric leg lift (kg)	0	-	0	-	0	-	0	-	4	14.8	4	4.4	64	100	23	85.1	87	95.6

place ECPs at risk of lower back injuries and limit their ability to carry heavy patients and rescue equipment. Harthi and Rachman (2019) reported that the most common musculoskeletal injuries among paramedics and emergency medical technicians in the United States and Australia were sprains and strains caused by lifting and moving patients, leading to increased absenteeism, work dissatisfaction, and career-ending injuries.[24]

Almost 60% of the participants demonstrated poor grip strength. Activities that need to be performed by ECPs include repetitive grasping and holding of stretchers loaded with patients of different sizes and weights, and heavy rescue equipment. In addition, they participate in emergency activities such as victim drag (for example, where a patient is dragged from a burning car or the scene of an accident to safety), other rescue activities where manual handling tools (e.g. hydraulic cutters and spreaders) are used, and other dangerous activities. Insufficient grip strength is associated with work-related accidents and injuries.[25] Poor grip strength can lead to accidents such as dropping patients during lifting or carrying activities, and adversely affects the ability to carry and use rescue equipment. Adequate cardiopulmonary resuscitation (CPR) compressions cannot be performed on patients when ECPs have poor grip strength,[26] which further compromises patient lives.

FLEXIBILITY

The ECPs in this study demonstrated adequate flexibility. Flexibility reduces the risk of injury when suddenly moving from inactivity to rapid movements.[14] Flexibility also reduces the incidence of lower back pain when performing duties that require dismounting from vehicles, emergency extrication, and continuous bending and reaching (e.g. rescuing patients in confined spaces).[14]

AEROBIC CAPACITY

More than 60% of the study participants had inadequate VO_2 max levels, indicating low aerobic capacity. Increasing aerobic capacity of ECPs enables strenuous tasks to be performed at a lower heart rate, thereby reducing the level of physical exertion during rescue activities. Hansen et al. (2012) found that oxygen uptake and heart rate were significantly lower in a group of physically fit healthcare professionals during a sustained CPR when compared to a group of sedentary healthcare professionals.[27]

ANAEROBIC CAPACITY

Approximately half of the study participants demonstrated adequate anaerobic capacity. Adequate anaerobic capacity is important because it improves both the aerobic capacity and anaerobic threshold level,[28] both of which are important for ECPs, especially when performing strenuous activities such as CPR.[27]

LIMITATIONS

Most field tests had inherent limitations such as the motivation of the participants to complete the test at their best effort, at all times. However, the researcher encouraged all participants to do the best that they could. The results cannot be generalised to ECPs across South Africa as the study was conducted on a small number of ECPs in one province and the response rate was low. Another limitation was that US norms were used to rate performances of the study participants as there were none available in South Africa. These norms have not been validated in South African populations.

RECOMMENDATIONS

Physical exercise programmes and activities should form part of ECPs' daily routines. An exercise programme intervention would prepare ECPs mentally and physically for the strenuous tasks required of them while on duty. Pre-employment physical fitness testing and periodical fitness assessments of ECPs should be implemented to measure workplace 'fit for duty' competency. Adequate physical fitness among ECPs would also contribute to the prevention of non-communicable diseases such as diabetes, hypertension and cardiovascular disease as well as improve immune response to communicable diseases such as the recent severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), also known as COVID-19.[29] Lastly, future research needs to focus on effective exercise programme interventions to facilitate weight loss among ECPs.

CONCLUSION

The relatively poor fitness levels and increased BMI demonstrated among the ECPs may prevent them from effectively performing their tasks on a daily basis, predispose them to injury as well as cardiovascular diseases and COVID-19, and place the lives of both patients and rescuers at risk. The activities required of ECPs are physically demanding and require higher levels of physical fitness than many other occupations. The ECPs' physical preparedness must be optimal for the successful execution of duties.

LESSONS LEARNED

- There is poor delivery of employee wellness programmes directed at ECPs in the North West province of South Africa.
- Participation in employee wellness programmes for ECPs may be poor.
- Entry level and pre-employment fitness programmes are not prioritised for ECPs, nor is there any regular monitoring of physical fitness.

DECLARATION

The authors declare that this is their own work; all the sources used in this paper have been duly acknowledged and there are no conflicts of interest.

AUTHOR CONTRIBUTIONS

Conception and design of the study: YC
Data acquisition: YC, SKM
Data analysis: all authors
Interpretation of the data: all authors
Drafting of the paper: SKM
Critical revisions of the paper: all authors
Accountability for all aspects of the work: all authors

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