Physical capacity of NSW Ambulance paramedics

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ABSTRACT

Background. Paramedics are among the most frequently injured health professionals in Australia. A lack of physical capacity may contribute to injury risk in this occupational population.

Aims. This study sought to describe and compare the physical fitness of male and female paramedics across age groups to ascertain differences in physical capacity.

Methods. A group of regional Australian paramedics (*n*=140; 78 male; mean±SD 37.4±9.9 years; body mass index 28.1±4.9 kg·m^2) underwent a fitness assessment. Measures included upper, lower and core-body muscular strength and flexibility. Outcomes were compared between genders and across age groups using two-way between-groups ANOVA.

Results. Male paramedics had greater upper body strength (p<0.05; push-ups) mean (95% CI): 22.6 (19.4-25.9) vs. 18.7 (15.2-22.3); similar lower body strength (single-leg wall squat): 39.0 (32.6-45.3) sec vs. 36.7 (27.1-46.3) sec; greater core strength (p<0.05; prone plank hold): 87.9 (77.6-98.3) sec vs. 73.8 (63.7-83.8) sec; similar upper-body flexibility (back scratch): -0.4 (-6.7- -1.3) cm vs. -0.3 (-2.2-1.7) cm; and similar lower-body flexibility (sit and reach): 20.4 (18.2-22.6) cm vs. 26.1 (23.5-28.7) cm to female paramedics. Core, upper and lower body strength all decreased with age (p<0.05).

Conclusions. Core, upper- and lower-body strength and upper-body flexibility were poorer for older compared to younger regional paramedics in NSW, Australia. Future research should investigate whether these outcomes are associated with occupational injury risk. This information would assist in the design of injury prevention interventions for paramedics such as tailored workplace exercise programs.

Key words. Occupational injury; Workplace; Physical fitness; Musculoskeletal

INTRODUCTION

Paramedics are mobile healthcare providers who work in the out-of-hospital setting. In delivering urgent care for sudden illness or traumatic injury, a paramedic's duties involve cognitive, psychomotor and physical demands. Duties include accessing patients, utilising lifting aids and transportation equipment, lifting and lowering patients on stretchers, and regularly bearing weight up to 50 kg [1]. In addition, tasks such as cardiopulmonary resuscitation place a high musculoskeletal demand on paramedics [2]. Such duties pose risk for developing work-related musculoskeletal disorders [3]. In Australia, a prospective paramedic must pass physical fitness tests prior to employment. However, they are not necessarily re-tested after gaining ambulance service entry, with the exception of specialist roles such as tactical paramedics [4]. Furthermore, the use of current pre-employment fitness testing for paramedics as a predictor of subsequent occupational injury is invalid based on a review of current evidence [5]. With high rates of injury for paramedics internationally [6, 7], an examination of paramedic physical fitness across age brackets and gender is necessary [5, 8].

The latest Australian workers' compensation statistics indicate that the incidence rate of serious injury claims for community and personal service workers decreased from 20.3 to 14.2 per 1000 employees between 2000-01 and 2016-17 [9]. While this is positive, these workers represented the third-highest serious injury claims occupational category behind labourers (23.7 claims per 1000 employees) and machinery operators and drivers (21.1 claims per 1000 employees), well above the average of 9.3 claims per 1000 employees across all occupational categories [9]. These latest statistics do not detail injury claim rates for paramedics specifically, however, historical data provide insights. For example, New South Wales (NSW) recorded the highest average workers compensation injury claim rate for paramedics (199.9/1000 workers per year) of all Australian states and territories during 2009-14 (median time loss 2.0 weeks) [10]. The primary mechanism was muscular stress injury while lifting, carrying, or putting down an object (37.3%; similar to the US rate of 37%) [6], and the primary injury locations were the lower back (27.0%), shoulder (11.1%) and knee (6.6%) [10].

More recent insurance data from 2017-18 show that paramedics in NSW had an average 79 days off work per injury claim compared to an average 39 days for health and community service occupations overall, and a greater proportion of paramedic injury claims were due to body stressing injuries (59% vs. 34%) [11]. The nature of these compensable injuries highlights the need for paramedics to achieve and maintain an adequate level of muscular strength to effectively perform their duties and avoid injury [8]. In 2015-16, there were approximately 16,000 full-time equivalent paramedics in Australia, of which approximately 35% were female [12]. While data are not available comparing injury rates between male and female Australian paramedics, US research suggests female paramedics have a disproportionally high risk of occupational injury [13]. It is therefore important to compare the physical capacities and characteristics of male and female paramedics, as gender-specific differences may exist which require tailored injury-prevention interventions.

To date, there has not been a focused effort to study the health status of paramedics by geographic work area, most particularly, the rural (remote and very remote) and regional paramedic population. Approximately 50% (of the ≈4000 officers) of the NSW Ambulance workforce are posted to rural and regional stations. Similar to overall rural and regional populations, healthcare professionals living in these areas may suffer higher rates of back pain and associated problems along with increased mortality, arthritis, asthma, chronic obstructive pulmonary disease, cardiovascular disease, diabetes, cancer and major mental health problems compared to those living in major cities [14]. The limited available health data on paramedics indicate the average Canadian, American and Australian paramedic is classified as overweight or obese based on body mass index (BMI), increasing injury risk [15, 16]. Furthermore, a group of male metropolitan Western Australian conventional and special operations paramedic officers demonstrated levels of muscular strength and endurance no greater than the general public, despite the physically demanding nature of their duties [17]. These findings are of particular concern regarding older paramedics, as rates of serious musculoskeletal injury claims increase with age [9, 18].

There is a need for a more detailed understanding of age- and gender-specific factors that may contribute to the high injury rates of paramedics, including physical fitness attributes [7]. The primary aim of this study was to describe the physical fitness levels of male and female paramedics across age groups in rural and regional NSW Australia, in order to inform the design and development of targeted injury prevention interventions aiming to reduce musculoskeletal injury risk in this occupational population.

METHODS

This cross-sectional study was conducted from October to November 2017 and is reported in accordance with the STROBE statement. Paramedics from 37 regional and rural ambulance stations across western NSW, Australia were invited via email and posters placed within each station to take part in the study. The number of paramedics based at each station ranged from 2-24 (mean = 8). Together, these stations comprise Central Western Zones 1 and 2 of NSW Ambulance. The study was approved by the Human Research Ethics Committees of the South Eastern Sydney Local Health District (HREC 17/104) and Charles Sturt University (H17149). Paramedics aged 18-65 years who were free from any uncontrolled condition for which exercise is contraindicated (e.g. uncontrolled hypertension, uncontrolled metabolic disease) [19] and were not returning to work from a musculoskeletal injury within the past six months or on any return to work program were eligible for inclusion. Participants provided written informed consent prior to participation after receiving both a written and verbal explanation of the study protocol and its potential risks and benefits.

Primary outcomes were measures of muscular strength (push-ups, plank and wall squat). Secondary outcomes were measures of flexibility (sit and reach, back scratch). All participants were instructed to maintain their usual dietary intake and to avoid strenuous exercise for 48 hours prior to each testing session. Data were collected onsite at each ambulance station by a team of researchers who were trained by an accredited exercise physiologist to perform each test. At the time of testing participants were either on duty, or they were off duty but elected to attend the

station to perform the testing and be included in the study. Tests were performed in the order stated. Upper body (shoulder) flexibility was assessed on both left and right sides by the back scratch test. Hamstring flexibility was assessed by a standard sit and reach test [19]. For both the shoulder and hamstring flexibility tests, the mean of two correctly executed trials was recorded unless there was a >5mm difference between attempts, in which case a third trial was performed and the median recorded as the final score. For shoulder flexibility, the mean of left and right sides was then taken as the final score and used in analyses.

Upper body strength was assessed by a maximal push-ups test performed on the toes for men, and knees (i.e. modified) for women [19]. Lower body strength was assessed by a single leg static squat test (wall squat) [20]. Maximum duration for each leg was summed to obtain a single static squat score (seconds). Core strength was assessed by a plank hold test [21] Anthropometric measurements (body mass, stature and waist circumference) were taken using standardised protocols [19].

All data were analysed using the Statistical Package for Social Sciences (SPSS for Windows, vers. 25.0, SPSS, Inc., Chicago, IL, USA). Data are presented as mean (95% CI) unless otherwise specified. An alpha level of 0.05 was set as significant for all statistical testing. A priori sample size calculation was based on an expected medium effect size (d = 0.4) for differences in strength between genders, resulting in a required sample of 64 per group or a total of 128 participants to achieve 80% power. Two-tailed independent samples t-tests compared physical characteristics between genders, and compared age and years of service between the target population and actual study sample. The musculoskeletal fitness of participants (upper body, core and lower body strength and upper body and lower body flexibility) were compared between age groups (20-29, 30-39, 40-49, 50-59) and genders (male and female) using two-way between-groups ANOVA. Effect sizes are reported as partial eta squared (0.01 = small; 0.06 = moderate; and 0.14 = large). Normality was checked visually and statistically using the Kolmogorov-Smirnov statistic before analysis. For non-normally distributed variables, data were transformed (square root transformation applied for push-

ups, static squat and plank; reflect and square root applied for back scratch) to achieve normality prior to analysis. Musculoskeletal fitness results were interpreted against normative data from the American College of Sports Medicine (ACSM) where available [19]. Some participants could not perform certain tests that were maximal-effort in nature due to previous or current injury to a specific body location, and final participant numbers for each test are provided in the footnote of Table 2.

RESULTS

Of the potential 308 paramedics (183 male; 125 female; ratio = 1:0.68) based at the 37 ambulance stations in the study catchment area, 140 (78 male; 62 female; ratio = 1:0.79) enrolled in the study representing an overall response rate of 45.5%. All paramedics who expressed an interest in participating in the study were deemed eligible after completing initial health screening. The remaining 168 paramedics did not express an interest in participating and were not contacted by the researchers. Two of the possible 37 ambulance stations were not represented as no paramedics from these stations chose to participate in the study. Compared to the target population of 308 paramedics, the 140 participants who took part in the study were younger (mean±SD: 37.4±9.9 vs. 40.9±11.0 years; $p<0.01$) and had completed fewer years of paramedic service (mean±SD: 9.3±6.3 vs. 12.1±9.6 years; $p<0.01$). Compared to female participants, males were a mean 5.7 years older (this age-gender difference was 8.5 years in the overall target population of 308 paramedics) and were taller, heavier and larger around the waist (Table 1; $p<0.001$). On average, both males (28.6 $kg \cdot m^2$) and females (27.4 $kg \cdot m^2$) were classified as overweight based on BMI (Table 1) [19]. Obesity-related disease risk was low and moderate for females and males respectively, based on waist circumference (Table 1) [19].

Table 1 here

Musculoskeletal fitness results are presented in Table 2. No significant age x gender interaction effects were observed for any fitness measure (p>0.05). Significant effects for age were observed for the push-ups (p<0.01; moderate effect), plank (p<0.05; moderate effect), static squat (p<0.01; large effect) and back scratch (p<0.001; large effect) tests. Specifically, upper body strength and upper body flexibility were both lower for participants aged 40-49 and 50-59 years compared to those aged 20-29 years, and lower for those aged 50-59 years compared to those aged 30-39 years. Core strength was lower for participants aged 50-59 years compared to those aged 20-29 years. Lower body strength was lower for participants aged 40-49 and 50-59 years compared to those aged 20-29 years. Males had greater upper body and core strength compared to females (p<0.05; small effect sizes).

Table 2 here

DISCUSSION

Despite the physically demanding duties that paramedics must routinely perform such as patient lifts and carries, a lack of core strength was observed in regional and rural paramedics in NSW, Australia. Furthermore, both female paramedics and paramedics of both genders aged over 40 years had lower levels of physical strength, with previous occupational injury statistics suggesting that these employees may be at a greater risk of sustaining occupational injuries compared to younger, male employees [9, 13, 18]. Given the limited comparable emergency services health and fitness data available, results were compared to ACSM normative data. In reference to ACSM normative data, all age-gender categories achieved a fitness ranking of 'good' or 'very good' for upper-body strength, while only females aged 30-39 and males aged 40-49 achieved a ranking of 'good' for hamstring flexibility with all other age-gender categories ranked as either 'fair' or 'poor'. Plank hold test results were well below that of male and female Canadian firefighters (mean = 145 seconds for both genders) of similar mean BMI (28.0 $kg \cdot m^2$) and age (40 years) to the participants in this study [22]. Furthermore, all except one age-gender category (males aged 20-29 years) failed to

achieve a mean plank hold of 72.5 seconds, the mean score achieved by male and female adults of similar mean age (34.0 years) without back pain in a previous study (vs. a mean 28.3 seconds in adults with chronic mechanical back pain) [23]. There were no normative data available for the static squat or back scratch tests, however, performance was poorer for paramedics aged 40-59 years compared to those aged 20-29 years.

It is important to acknowledge that this study was cross-sectional in nature, conducted only in regional and rural paramedics, and participants were younger with less accrued paramedic experience than the overall target population. Whilst the generally more experienced paramedics who did not enrol in the study may have had a lower injury risk [16], our study shows poorer whole-body muscular strength and upper body flexibility with moderate to large effect sizes for older paramedics, thereby increasing musculoskeletal injury risk given exposure to the same physical occupational demands [18]. The highest frequency rate of serious musculoskeletal injury claims in Australia in 2016-17 was for employees aged 60-64 years, while employees aged 25-29 and 30-34 years had the lowest rates (6.8 vs. 4.1 and 3.9 claims per million hours worked, respectively) [9]. Older workers also recorded the highest incidence rates of serious musculoskeletal injury claims (9.6-10.9/1000 and 6.7-8.1/1000 employees for ages 45-64 and 20-44 years, respectively) [9]. This is particularly concerning given the fact that healthcare and social assistance workers represent 12% of the Australian workforce and are a rapidly ageing demographic, with 36% now aged over 50 years [24]. Compounding this is the inconsistent national approach to physical health and fitness entry testing for paramedics. Two Australian paramedic services appear to have defined job entry health standards that quantify the demands of paramedic duties [1, 25]. Furthermore, there is a lack of a required demonstrable level of paramedic health and fitness once employed, save for example, paramedic special team standards [26]. Whilst the reasons for non-participation were not investigated in this study, it is possible that paramedics with a stronger affinity towards exercise chose to participate (i.e. selection bias) [27] and/or those with previous musculoskeletal injuries or medical conditions chose not to participate. Had a greater proportion of the overall paramedic

population participated (including older paramedics), mean fitness outcomes may have been poorer than those observed in the current sample.

Lifting, carrying and putting down objects are the primary causes of compensable occupational injuries in Australia and the most common injury sites are the lower back and shoulder [10]. Male paramedics may have a lower risk of injury to these locations than female paramedics because they possess greater upper body and core strength. This finding is supported by research in the US which found that despite only comprising 27% of the study population, female emergency medical technicians and paramedics accounted for a similar volume of occupational injuries (53%) to males between 2006-08, the majority of which (45%) were sprains, strains or tears [6, 13]. Gender-specific injury risks have not been established in emergency services personnel, and should be a focus of future research. Such information would help to inform the development of occupational injury prevention programs such as workplace exercise programs, which may need to account for age- and gender-specific differences in physical capacity. Specifically, female paramedics may require programs that focus more heavily on the development of upper body and core strength. Furthermore, it is unknown whether paramedic crew composition (i.e. male:female ratio) and/or the introduction of powered lifting products (powered stretchers, self-loading stretchers, powered or power-assisted stair chairs) might reduce injury rates [28].

BMI has been positively correlated with occupational injury incidence, lost workdays due to injury and medical and indemnity claims costs across several occupations, with higher rates of claims for more physically demanding jobs [16]. The paramedics involved in the current study were on average rated as overweight based on BMI and may therefore be at an increased risk of musculoskeletal injury, especially workers categorised as obese [15]. In particular, BMI is positively associated with occupational back pain, shoulder and lower extremity injuries such sprain, strain, and inflammation-related injuries from lifts, slips, trips and forceful exertions [16]. Not only are occupational injury claims more frequent for workers with a higher BMI, but the costs per claim and the number of lost workdays due to injury also increase, creating a much larger overall injury-related

expense with increasing BMI [16]. Although the physical capacity of metropolitan paramedics was not investigated in this study, data indicate that regionally-based paramedics (*n* = 378) have a higher BMI than their metropolitan-based counterparts (*n* = 368) in NSW, Australia (27.5 ± 4.3 $kg \cdot m^2$ vs. 26.6 ± 5.1 $kg \cdot m^2$) [29], and may therefore be at greater risk of sustaining occupational musculoskeletal injuries especially if they are concurrently less physically active as population-level data suggest [14]. Our findings indicate that injury prevention initiatives for paramedics such as workplace exercise programs should account for age- and gender-specific differences in physical capacity, which may include personal-level assessment, prescription and delivery [30].

In addition to having an overweight BMI on average, insufficient physical strength of paramedics based in regional and rural NSW, Australia, places them at increased musculoskeletal injury risk while performing their physically demanding occupational duties. Both older (40+ years) and female paramedics may be at greater injury risk due to lower physical capacity, particularly for those individuals rated as obese. These age and gender differences should be taken into account along with specific individual-level weaknesses when designing injury prevention interventions for paramedics such as workplace exercise programs. Such programs are recommended to improve physical capacity and reduce occupational injury risk, and should include personal health and fitness assessment with exercise prescription tailored at the individual level.

KEY LEARNING POINTS

What is already known about this subject:

- Paramedics have a high occupational musculoskeletal injury rate, up to seven times higher than the national average in Australia.
- The primary cause of occupational musculoskeletal injuries in Australia is manual handling, with injuries occurring most frequently to the lower back, shoulder and knee.

- BMI is positively associated with musculoskeletal injury risk, and paramedics (particularly regional and rural) are rated (on average) as overweight based on BMI and higher than the average Australian adult.

What this study adds:

- Upper body strength and flexibility, and both lower body and core strength decrease with age for both male and female paramedics.
- Female paramedics have lower levels of upper body and core strength than male paramedics yet are required to perform the same physically demanding duties such as patient lifts and carries.

What impact this may have on practice or policy:

- Ambulance stations should consider providing paramedics with opportunities to improve their physical capacity such as the implementation of guided, targeted workplace exercise programs.
- Differences in the physical capacity profiles of male and female paramedics at different ages suggest that workplace exercise programs should be individually tailored.

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Table 1.
Physical characteristics of participants.

	Males (*n* = 78) Mean (95% CI)	**Females (*n* = 62) Mean (95% CI)**
Age (years)	40.1 (37.7-42.5)	34.4 (32.1-36.2)***
Height (cm)	181.1 (179.5-182.6)	166.7 (164.8-168.5)***
Body mass (kg)	94.2 (90.8-97.6)	77.9 (73.2-82.7)***
BMI ($kg \cdot m^2$)	28.6 (27.6-29.5)	27.4 (26.0-28.9)
Waist circumference (cm)	99.6 (96.6-102.6)	86.9 (82.8-91.0)***

BMI = body mass index; *n* = number of participants. Significant difference between genders indicated by ***($p<0.001$).

Table 2.
Musculoskeletal fitness of participants by age group.

Variable	Gender	Age group								Effects					
		20-29		30-39		40-49		50-59		Interaction		Age group		Gender	
		Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	*p*	ES	*p*	ES	*p*	ES
Push-ups (n)	M	31.3	24.6-38.0	26.2	16.8-35.6	20.3	15.5-25.1	14.1	9.2-19.1	0.93	0.00	**<0.01** ◊¶§	0.11	**<0.05**	0.05
	Fitness category	Very good		Very good		Very good		Very good							
	F	21.8	14.1-29.5	20.2	14.6-25.8	14.6	7.7-21.6	6.7	5.2-8.1						
	Fitness category	Very good		Very good		Very good		Good							
Plank (sec)	M	103.4	85.7-121.1	90.6	66.4-114.9	89.6	67.3-112.0	68.2	48.8-87.5	0.60	0.01	**<0.05** ¶	0.07	**<0.05**	0.05
	F	84.7	61.2-108.2	79.6	66.1-93.1	53.3	37.5-69.0	37.7	4.7-70.7						
Static squat (sec)	M	53.6	38.4-68.7	47.3	34.1-60.4	30.4	20.7-40.2	24.4	16.2-32.7	0.45	0.03	**<0.01** ◊¶	0.15	0.39	0.01
	F	58.4	27.1-89.6	30.5	21.8-39.3	28.2	12.7-43.8	15.8	-37.5-69.0						
Sit and reach (cm)	M	22.5	18.3-26.6	20.4	13.9-26.9	21.4	17.3-25.6	16.1	11.8-20.3	0.47	0.02	0.42	0.02	0.07	0.03
	Fitness category	Fair		Fair		Good		Fair							
	F	24.7	18.9-30.4	28.9	25.4-32.5	23.7	18.4-29.0	20.4	-104.8-145.5						
Back scratch (cm)	Fitness category	Fair		Good		Fair		Poor		0.49	0.02	**<0.001** ◊¶§	0.16	0.44	0.01
	M	3.1	-0.3-6.5	-4.6	-10.9-1.6	-4.1	-8.7-0.4	-11.1	-18.4- -3.8						
	F	3.8	1.3-6.3	0.6	-2.1-3.3	-5.4	-9.9- -0.9	-9.7	-32.4- 13.0						

Abbreviations: CI, confidence intervals; ES, effect size (partial eta squared). Data are presented as mean values±95% CI. *p* values obtained using between-groups analysis of variance. Bold font indicates statistical significance. ◊ indicates significant difference between 20-29 and 40-49, ¶ indicates significant difference between 20-29 and 50-59, § indicates significant difference between 30-39 and 50-59. Main effects reported for Gender and Age group; Interaction effects reported for Age group*Gender. Push-ups *n*=74 males, 61 females; Plank *n*=75 males, 61 females; Wall squat *n*=66 males, 46 females; Sit and reach *n*=73 males, 61 females; Back scratch *n*=73 males, 62 females.