

# Physical fitness and occupational demands of the Belfast ambulance service

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## Abstract

**The objectives of this study were to evaluate the current fitness of an area ambulance service based in Belfast and to quantify the physiological demands of accident and emergency work. From a total staff of 230, 105 (46%) volunteered to undergo a series of fitness tests subject to health state. Results based on body mass indices showed that 52% of subjects could be classified as overweight and 10% of subjects as obese. Fitness levels were similar to other comparable samples and showed the expected but not inevitable decrease with age. A simple work related task (walking at 6 km/h) performed in the laboratory showed that 54% of men over 40 years of age and 24% under 40 found it taxing. This would favour selection for accident and emergency work on the basis of functional capacity rather than chronological age. Accident and emergency work consisted of long periods of inactivity interspersed with shorter periods of relatively intense activity, often above the anaerobic threshold. Lactate concentrations measured during a staged emergency incident also suggested that personnel may work at intensities exceeding their anaerobic threshold. The incorporation of physical fitness standards in the ambulance service may be appropriate and consideration should be given to a reduced age of retirement.**

Of the recognised emergency services (fire, police, and ambulance) least is known about the physical characteristics and occupational demands of ambulance personnel. This is despite the widespread

belief that the occupation is a physically stressful one. Accident and emergency ambulance staff may be required to lift and transfer patients from awkward positions and to carry out manual resuscitation techniques for extended periods. Furthermore, exposure to shift work may exacerbate the physical stresses of the job.<sup>1</sup> Although minimal medical standards are recommended for those driving ambulances,<sup>2</sup> no written standards exist for health or fitness with regard to non-driving duties—namely, lifting and handling patients, carrying out resuscitation procedures, and other related tasks. Of particular concern for the United Kingdom ambulance service is the number of days lost through sickness. On average, 11 days are lost per employee each year.<sup>3</sup> Musculoskeletal disorders account for 50% of absences from work in the ambulance service compared with 16.6% for all types of work at a national level.<sup>3</sup> Such injuries can sometimes lead to demotion from accident and emergency duties or even the termination of employment. Evidence exists to indicate that an increase in physical fitness can decrease absence due to sickness, increase work performance,<sup>4</sup> and decrease the number of work related injuries.<sup>5</sup>

The purpose of this study was to evaluate the current level of physical fitness in the staff of an area ambulance service and to quantify the physiological demands of accident and emergency duties. We are unaware of any comparable information at present for the United Kingdom ambulance service.

## Methods

Participation in this cross sectional study was on the basis of informed written consent. The project was voluntary and withdrawal was permitted on request. Approval from the local medical ethical committee was received before the study.

From a total ambulance service staff of 230, 105 (46%) volunteered to participate. Of these, 94 were men and 11 were women. From the results of a preliminary examination, three male subjects were considered unfit for further participation. Although results for the female subjects are included, detailed discussion on these is precluded by the small size of our sample.

Measurements of height, weight, trunk flexibility,

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and hand grip strength<sup>6</sup> were taken, and body mass index (BMI) calculated.<sup>7</sup> Waist girth taken from current uniform trouser size was also noted for both participants and non-participants.

A submaximal test of physical working capacity equivalent to 85% of age related maximum heart rate (PWC<sub>85%</sub>)<sup>8</sup> was also performed on a cycle ergometer. Scores were converted into predicted maximal oxygen uptake ( $\dot{V}O_{2max}$ ) values according to the formula of Shephard.<sup>9</sup>

From the sample, 20 male volunteers underwent further laboratory testing for validation purposes. The maximal nature of the test protocol required participants to be under 40 years of age and free from negative medical screening factors. Leg extension strength was measured with a Cybex II isokinetic dynamometer (Lumex Inc, New York), and used to validate hand grip strength. This was found to adequately reflect the strength of larger, ambulatory muscle groups ( $r = 0.7, p < 0.0001$ ). The results from the PWC<sub>85%</sub> test were validated against those from a progressive, discontinuous treadmill test of  $\dot{V}O_{2max}$ , using an automated on line system of gas analysis (Oxycon IV, Mijnhardt BV, Holland). A correlation of  $r = 0.6$  ( $p < 0.005$ ) indicated that the PWC<sub>85%</sub> provides reasonable estimates of directly measured  $\dot{V}O_{2max}$  in line with previous studies.<sup>10</sup> During the assessment of  $\dot{V}O_{2max}$ , capillary blood samples were collected from the ear lobe for subsequent lactate analysis with an automated system (Analox Ltd, England). A concentration of 4 mmol/l was used to establish the so called "anaerobic threshold."<sup>11</sup> This is the intensity of physical work beyond which aerobic sources can no longer sustain energy requirements, resulting in a rapid onset of metabolic acidosis and muscle fatigue.<sup>12</sup> Heart rate was also continuously monitored during the treadmill test. To assess the relative physical stress of an everyday task on the cardiovascular system, oxygen uptake at a brisk walking pace (6 km/h) was measured on the treadmill and expressed as a percentage of  $\dot{V}O_{2max}$ .

From the subgroup of 20 men, eight subjects agreed to participate in the assessment of accident and emergency duties. A total of 21 working shifts were assessed in the field using portable heart rate telemetry systems (Polar Electro, Finland).

Stored heart rate data were downloaded onto a computer (IBM Model 5155) for further analysis. As heart rate and work output are related linearly between moderate and heavy workloads,<sup>13</sup> the heart rate data could be interpreted in terms of occupational workload relative to the subject's previously measured maximum aerobic power and anaerobic threshold.

Finally, a simulated emergency incident similar to that which might be experienced in the field was performed under controlled conditions. The same

eight volunteers were divided into pairs and asked to run up five flights of 11 stairs (18 cms) to the scene of the incident (stage 1). After assessing the situation they descended the stairs to collect equipment (stage 2) before returning to the scene (stage 3). The incident was completed when the ambulancemen carried the patient (body weight 70 kg) downstairs to the starting point (stage 4). Heart rate response was monitored continuously and blood lactate concentrations were measured at each stage during the incident.

Standard statistical methods were used in the analysis of the data. The Pearson product-moment was employed for the correlation of experimental procedures and Student's *t* test was employed for the comparison between participants and non-participants.

## Results

Any interpretation of results must allow for the magnitude of the response rate (46%) and the voluntary nature of participation in the study. Regarding the second, it could be surmised that volunteers tended to be "fitter" or have more confidence in their physical abilities for the job than the non-participants. This is supported by comparing the ages—namely, 37 (SEM 1) years for participants and 44 (SEM 0.8) years for non-participants—indicating an age bias in the sample. No significant difference was seen, however, between the two groups for waist girth obtained from current uniform sizes. Table 1 shows the characteristics for participants. Most BMIs (56% of subjects) were above the acceptable range of 20.1–25 kg/m<sup>2</sup><sup>14</sup> and 10% of subjects were above 30 kg/m<sup>2</sup>, commonly recognised as the threshold of clinical obesity.<sup>7</sup> Although only a small population of female staff were assessed, a substantial difference in hand grip strength between men and women was found. Women, however, possessed a higher level of flexibility (table 1).

Table 2 shows predicted  $\dot{V}O_{2max}$  values for different age groups. The present study sample is similar to two other comparable samples in terms of aerobic fitness.<sup>8,15</sup>

Table 1 Characteristics of subjects

Characteristics	Men (n = 91)	Women (n = 11)
Age (y)	37 ± 1.0	30.1 ± 0.4
Height (m)	1.74 ± 0.01	1.69 ± 0.02
Weight (kg)	79 ± 2	68 ± 4
Body mass index (kg/m <sup>2</sup> )	26 ± 0.5	23 ± 0.9
Hand grip strength (kg)	48 ± 1	33 ± 2
Flexibility (cm)	17.4 ± 0.8	20.7 ± 2.1
Predicted $\dot{V}O_{2max}$ (ml/kg/min)	37 ± 1	32 ± 2

Results are presented as mean ± SEM.

Table 2 Mean predicted  $\dot{V}O_{2\max}$  from three studies

Age (y)	Present ambulance study (1990)	Welsh heart programme (Cooke <sup>8</sup> )	Cadbury Schweppes (Tuxworth et al <sup>15</sup> )
25-34	43.8 ± 1.7 (31)	40.2 (157)	—
35-44	35.7 ± 1.4 (30)	36.6 (215)	33.4 (445)
45-54	29.3 ± 1.6 (16)	32.2 (171)	29.4 (557)
≥55	25.9 ± 2.6 (8)	30.1 (126)	26.2 (342)

Results from the present study are presented as mean ± SEM. Figures in parentheses refer to sample size.

Figure 1 shows the energy expenditure required to perform one common form of physical effort—namely, walking at 6 km/h—in comparison with the sub-group  $\dot{V}O_{2\max}$  and anaerobic threshold. The last was calculated to occur at an energy expenditure of 58% of  $\dot{V}O_{2\max}$ . This agrees closely with other estimated thresholds of high physical stress.<sup>15,16</sup> In our present study 46% of men over 40 found walking at 6 km/h comfortable (that is, below their estimated anaerobic threshold). Conversely, 24% of personnel under 40 found the task to be demanding to the extent that prolonged performance might be compromised by peripheral muscle fatigue.<sup>12,17</sup>

For the eight volunteers, several episodes of extended vigorous activity were apparent from the heart rate recordings made during normal shift work. Figure 2 shows an example of this. From 21 recorded shifts six periods of high activity including cardio-

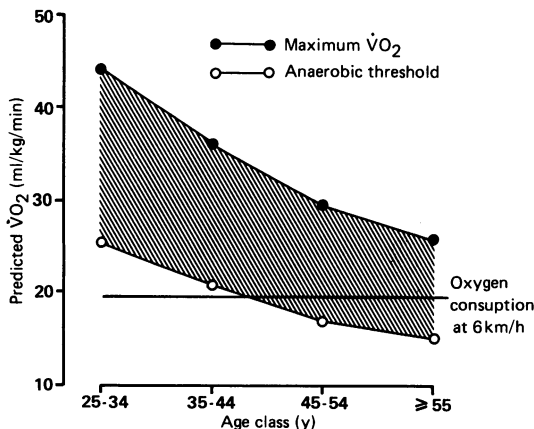


Figure 1 The energy expenditure in terms of oxygen consumption required to walk at 6 km/h. Maximum oxygen uptake ( $\dot{V}O_{2\max}$ ) was predicted from a submaximal cycle ergometer<sup>3</sup> on 91 men. Anaerobic threshold (AT) was derived from blood lactate measurements made on 20 men during a progressive, maximal treadmill test. The shaded area of the graph therefore represents strenuous physical activity about the AT. The mean value was fixed at 58% of predicted  $\dot{V}O_{2\max}$ . Oxygen consumption at 6 km/h walking pace was measured directly on the same 20 men, and a mean SEM value derived ( $19.4 \pm 0.4$  ml/kg/min).

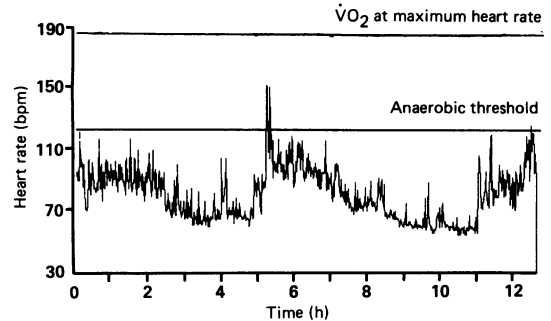


Figure 2 A typical field recording of heart rate. Recordings were taken during a typical 12 hour shift using a portable heart rate telemetry system (Polar Electro, Finland), and measured as beats per minute. The anaerobic threshold and  $\dot{V}O_{2\max}$  heart rate were calculated from a treadmill test.

pulmonary resuscitation and chair carrying raised heart rate above anaerobic threshold values for periods of up to 11 minutes. Extended periods of moderate activity including the response to a road traffic accident and patient transfers caused a raised heart rate approaching threshold values for longer periods.

The observation that ambulancemen may be required to perform physical tasks at high relative intensities was also shown by the simulated emergency incident (table 3). A mean heart rate of 150 beats a minute (range 129–162) was reached ( $n = 8$ ) during the exercise, representing 60% of  $\dot{V}O_{2\max}$  of the personnel as identified by the treadmill test. Lactate concentrations as high as 4.8 mmol/l (range 3.5–6.0) were found at the end of the exercise. The mean time taken to perform the manoeuvre was eight minutes 26 seconds.

## Discussion

To date the occupational demands and levels of physical fitness required to effectively carry out

Table 3 Mean heart rate and mean end lactate concentrations at each stage of emergency incident

Stage no	Maximum heart rate (beats/min)	Mean heart rate (beats/min)	Mean end lactate concentration (mmol/l)
Rest	—	—	1.25 ± 0.1 (1.0–1.6)
1	152 ± 4.2 (124–160)	142 ± 4.2 (121–156)	2.1 ± 0.3 (0.7–3.4)
2	136 ± 5.9 (105–150)	130 ± 5.3 (104–141)	3.1 ± 0.3 (1.8–4.4)
3	160 ± 3.7 (138–172)	150 ± 3.9 (129–162)	3.8 ± 0.3 (2.8–4.9)
4	158 ± 6.5 (128–188)	148 ± 5.7 (122–162)	4.8 ± 0.3 (3.5–6.0)

Results are presented as mean ± SEM (range) for eight subjects. (Refer to text for stage categorisation.)

accident and emergency duties within the ambulance service have not been quantified. Firefighting duties, on the other hand, have been shown to require high levels of muscular strength and endurance coupled with a near maximum aerobic capacity.<sup>18</sup> Improvements in the fitness of firemen in response to an exercise programme resulted in significant decreases in the time taken to perform tasks such as rescuing dummies, pulling hoses, and climbing ladders.<sup>19</sup> Similarly, a health and fitness strategy implemented within the Californian Highway Patrol over an 18 month period substantially increased the proportion of officers who passed an ergometer test representing the physiological stresses of police work from 59% to 76%.<sup>20</sup>

Cardiovascular fitness was similar to other comparable male populations and displayed an expected decline with advancing age (table 2). Strong evidence exists to suggest that the decline in exercise capacity is neither inevitable nor permanent. Moderate training may well retard the decline in maximal oxygen uptake and offset the deterioration in physical working capacity in middle aged and elderly people.<sup>21</sup> For personnel over 40 years of age, walking at 6 km/h was sufficient to raise heart rate above anaerobic threshold values in 54% of men. In the under 40 age group, 24% of men found the task difficult.

Body mass indices were found to fall outside accepted norms.<sup>7</sup> In the present study, 56% of adult men were overweight and 10% of these were classified as obese. Results from a local survey<sup>22</sup> categorised 41% of adult men as overweight and 8% obese. The part played by obesity as a major cause of morbidity either directly or due to the effects of associated factors is widely recognised.<sup>7</sup>

The energy costs of walking and running are proportional to body weight and speed. This would suggest that personnel classified as overweight are required to use a larger percentage of their physical working capacity for a given work related task than leaner subjects. Considering the nature of accident and emergency work, concern must be expressed at the high levels of obesity in the service.

Ageing is characterised by a reduced ability to adapt to and recover from physiological stress. The greater the stress, the smaller the reserve capacity of the older individual compared with the younger person. At present recruitment and promotion to accident and emergency work is restricted to applicants younger than 40. This reliance upon chronological criteria may be misleading, and potentially dangerous in an emergency situation. Results from the walking test suggest that selection based on functional criteria would be more satisfactory.

Hand grip strength was average for men.<sup>23</sup> Further investigation is necessary to determine strength guidelines required for the service to enable personnel to carry patients safely particularly in view of the high incidence of lower back pain.<sup>24</sup>

The need for high standards of physical fitness for ambulance personnel is highlighted by the nature of accident and emergency work as seen both in the field and in simulated incidents. Long periods of inactivity were interspersed with bouts of relatively intense activity, often well above the anaerobic threshold and lasting for several minutes. Musculo-skeletal injuries, which are a major concern within the ambulance service, have been shown to occur more frequently when those involved become fatigued.<sup>5</sup> An increase in physical fitness among personnel may decrease the frequency of such episodes. The benefits of improved fitness might be cost effective in reducing absence due to sickness.<sup>19, 25</sup>

It may be appropriate to consider the introduction of physical fitness standards for new recruits. Before these could be introduced, however, further research is required to establish appropriate and valid limits for such standards. For those staff already employed, opportunities and facilities for the improvement of physical fitness should be introduced along with opportunities for regular assessments and appropriate advice. In view of the evident physical demands of the ambulance service, consideration should be given to a reduction in the age of retirement.

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- Harma M, Ilmarinen J, Knauth P. Physical fitness and other individual factors relating to the shiftwork tolerance of women. *Chronobiol Int* 1988;5:417-24.
- Raffle A. *Medical aspects of fitness to drive. A guide for medical practitioners*. London: The Medical Commission on Accident Prevention, 1985.
- Ambulance Council Working Party. *The problems of long serving ambulancemen*. London: Report to the Secretary of State for Health, 1988.
- Donoghue S. The correlation between physical fitness, absenteeism and work performance. *Can J Public Health* 1977; 68:201-3.
- Rogers C. Firing up for fitness. *The Physician and Sports Medicine* 1984;12:134-43.
- Council of Europe Committee for the Development of Sport. *Handbook for the Eurofit tests of physical fitness*. Rome: CECDs, 1988.
- Royal College of Physicians. Obesity. *Journal of The Royal College of Physicians of London* 1983;17:5-65.
- Cooke CB. *Clinical survey manual heart beat report No 3*. Cardiff: Welsh heart programme directorate, 1986.
- Shephard RJ. Computer programs for solution of the Astrand nomogram and the calculation of body surface area. *J Sports Med Phys Fitness* 1970;10:206-10.
- Paliczka VJ, Nichols AK, Boreham CAG. Validation of a field test of endurance as a predictor of maximal aerobic power and running performance in adults. *Brit J Sports Med* 1987;21: 163-6.

- 11 Heck H, Mander A, Hess G, Muche S, Hollman W. Justification of the 4 mmol/l lactate threshold. *Int J Sports Med* 1985;6:117-30.
- 12 Roberts D, Smith DJ. Biochemical aspects of peripheral muscle fatigue. A review. *Sports Med* 1989;7:125-38.
- 13 Rodahl K, Vokac Z, Fugelli P, Vaage O, Maehlum S. Circulatory strain, estimated energy output and catecholamine excretion in Norwegian coastal fishermen. *Ergonomics* 1974;17:585-602.
- 14 National Advisory Committee on Nutrition Education. *Proposals for the nutritional guidelines for the health education in Britain*. London: Health Education Council, 1983.
- 15 Tuxworth W, Nevill A, White C, Jenkins C. Health, fitness, physical fitness, and morbidity of middle aged male factory workers. *Br J Ind Med* 1986;43:733-53.
- 16 Canada Fitness Survey. *National Survey of exercise, fitness and health: Prospectus*. Ottawa: 1988.
- 17 Karlsson J, Jacobs I. Onset of blood lactate accumulation during muscular exercise as a threshold concept. Theoretical considerations. *Int J Sports Med* 1982;3:190-201.
- 18 Davis PO, Dotson CO, Laine Santa Maria D. Relationship between simulated fire fighting tasks and physical performance measures. *Med Sci Sports Exerc* 1982;14:65-71.
- 19 Adams TD, Yanowitz FG, Chandler S, Specht P, Lockwood R, Yeh MP. A study to evaluate and promote total fitness among fire fighters. *Journal of Sports Medicine* 1986;26:337-45.
- 20 Superko R, Bernauer E, Voss J. Effects of a mandatory health screening and physical maintenance program for law enforcement officers. *The Physician and Sports medicine* 1988;16:99-109.
- 21 Suominen H. *Effects of physical training in middle-aged and elderly people—with special regard to skeletal muscle, connective tissue and functional ageing*. Studies in sport, physical education and health. Jyväskylä: University of Jyväskylä, 1978.
- 22 Evans AE, McCrum EE, Patterson CC. *The change of heart baseline clinical survey. A report to the Northern Ireland health promotion unit*. Belfast: Northern Ireland health promotion unit, 1990.
- 23 Bookwalter K. Grip strength norms for males. *Research Quarterly* 1950;21:249-73.
- 24 Cady LD, Bischoff DP, O'Connell ER, Thomas PC, Allan JH. Strength and fitness and subsequent back injuries in firefighters. *J Occup Med* 1979;4:269-72.
- 25 Bahrke MS. Voluntary and mandatory fitness programmes for firefighters. *The Physician and Sports medicine* 1982;10:126-32.

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