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FITNESS AND HEALTH MEASUREMENT IN AIR CREW

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ABSTRACT

To fulfil the various tasks and roles efficiently in the Royal Air Force good health is implicit but 'fitness' is not so specifically defined. Fitness relates to a task; it does not describe a state of health. Using a system of submaximal measurement of oxygen uptake (VO_2), skinfold thickness, weight and health parameters involving an actuarial scaled questionnaire and blood pressure measurement, a fitness profile was developed evaluating health and fitness. The physiologic characteristics of eighty-two aircrew, 90% fast-jet, fixed-wing and 10% rotary wing employed in search and rescue duties, were investigated in evaluating and developing the fitness profile. The results suggest that individual strengths and weaknesses can be identified simply and economically in a framework of physically educating the individual and also where necessary motivating him to make minor lifestyle modifications, the objective being to ensure his health compatible with his task fitness.

Key words: Fitness, Health parameters, Fitness profile, Lifestyle, Compatible, Task fitness.

INTRODUCTION

Past and present methods of evaluating fitness in military personnel have centred round the work by Balke and Ware (1959) and its modifications by Cooper (1970) in the form of a set run and time relationship giving a VO_2 max. Its main attraction has been its economy in use demanding only a measured distance and a stop watch. However, Cooper's Table of Fitness categories indicates that running 1.5 miles in 12 minutes could place the individual in the fair, good or excellent category; the range being from 40 to 52 $\text{ml.kg}^{-1}.\text{min}^{-1}$. The standard error of VO_2 max prediction using this test would be at least 14%. Katch et al (1973) stated that distance runs were uncontrolled exercise tasks where pacing errors could result in inconsistencies in the individual's true aerobic capacity. Similar criticism was cited by Jackson et al (1981) in a recent study who found that motivation is a major factor in the validity of distance runs for measurement of aerobic capacity. The

study also revealed a possible influence of the relationship of anaerobic and aerobic endurance in such tests.

To evaluate VO_2 max it was decided to use a computer programmed version of the Åstrand-Ryhming nomogram inclusive on a Tunturi cardiometer with constant heart monitoring. Shephard (1971) showed this method to have an error of 10%, statistically more attractive for field work than Cooper's timed run. The main advantage of this form of evaluation is that it can along with the other measurements form an educative framework of fitness and health counselling giving privacy and eliminating the connotation of athleticism pervaded by the various methods of timed runs. In addition this method provides an index figure, more valuable for future monitoring and more precise than the vague terms Fair, Good or Excellent. Appraisal of military fitness has, as initially stated, tended to centre on identification of cardio-respiratory fitness and little else except possibly cursory referral to standard weight charts. The purpose of this paper is to describe an evaluation which broadens the appraisal to include body composition and health parameters. Although much

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literature has shown fitness correlates poorly with health they do recognise that they do influence each other. Health appraisal has also been shown to be an excellent motivator to individuals to modify their lifestyles and improving their potential fitness (Allen, 1980). This broader approach is necessary in the Royal Air Force because unlike the Army where fitness, orientated around cardio-respiratory fitness, is both desirable and relevant to the majority of their tasks, the Air Force is less physical, and more sedentary in nature where, even for most ground crew, strength would be a more desirable factor. Through evaluation the individual's health and fitness parameters can be identified and through personal consultation, and the use of computer stored lifestyles based on work compiled by Larson and Michelman (1973), a self-tailored health and fitness lifestyle can be given.

These lifestyles although not part of this study paper do provide the facility for the individual to have a fitness lifestyle to follow and direct any necessary lifestyle modifications. This ensures individual remedies are task specific.

METHODS

Eighty-two aircrew (74 fast-jet, fixed-wing and 8 rotary-wing) participated in the study. Their physical charac-

teristics were height 180.42 ± 5.72 cm, weight 77.43 ± 9.83 kg and age 30.71 ± 5.53 years (means $\pm$ standard deviations).

Each individual answered the health status questionnaire (Fig. 1) based on standard actuarial risk factors and assigned from the total score to a risk category. Resting blood pressures were taken in a supine position using an electronic digital BP measuring unit (tim-101 Accuracy ± 3 mmHg, Pulse $\pm 5\%$) giving systolic and diastolic blood pressure and resting pulse read-outs.

Harpenden skinfold calipers were used to determine skinfolds over the biceps, triceps (midway between the olecranon and acromion), at the inferior angle of the scapula, and over the iliac crest along the lines of Linn. Two trials minimum were taken to ensure an average of less than one millimetre discrepancy. The summation of the four readings gave the per cent body fat using the table derived by Durnin and Womersley (1974).

Stress evaluation was based on subjective evaluation of their daily stress level, low being normal everyday level, moderate where an individual felt easily overwhelmed by daily stresses, at times unable to relieve it, high stress is where the individual required medicinal aid to relieve it, for example tranquilisers such as diazepam

HEALTH STATUS (Cardio-vascular risks)									
NAME						DATE			
Sex	Age	Relatives with Strokes or Coronaries	Blood Pressure	Fat %	Smoking per Day (Cigarettes)	Exercise — Pulse more than 120	Stress		
1 Female	1 16-29	1 One over 60	1 Systolic 140-160	1 ♀15-19 ♂14-18	3 1-5 (Pipe Risk)	1 Regular (Every Day)	1 Low		
3 Male	3 30-49	2 One under 60	3 Diastolic more than 100	3 ♀20-25 ♂19-24	5 6-19 (Cigar Risk)	3 Occasional (Once per Week)	3 Moderate		
5 Stocky Male	5 50-69	5 Two or more under 60	5 Systolic more than 160	5 ♀26-31 ♂25-30	7 20 or more	5 Sedentary (Once per Month)	5 High (Require Drugs)		
				7 ♀32- ♂31-		7 Slothful (Once per Year)			
								TOTAL	
SCORE									
Very low risk		4-7	Below average		13-17	Above average		25-30	
Low risk		8-12	Average		18-24	High risk (see G.P.)		31 and above	

Fig. 1: The Health Status questionnaire filled in by the investigator in this study.

and prescribed by the patient's own doctor. An objective but as yet unvalidated test of stress level developed in the use of the questionnaire was when asked by the subject how he could evaluate his level if described as the ability to smile indicated low stress, if moderate stress it was difficult to elicit a smile consciously or unconsciously. This statement although not scientifically validated did correlate highly with how the subject judged himself and their scores gained from a modified Holmes and Rahe 'Life Change Rating Scale' (1967).

Height and weight were determined by the use of a stadiometer and clinical scales, respectively. Using the weight tables collated by the Metropolitan Life Insurance Co. (1959) the deviation from the norm was identified as a positive indice above the norm, or negative indice below the norm.

The measurement of VO_2 max was done submaximally on a Tunturi cycle ergometer ensuring the seat adjustment caused the subjects knee to be slightly flexed with the ball of the foot resting on the pedal at the lowest point in revolution. Constant heart rate monitoring was done using the Tunturi Cardiometer which also included the Åstrand-Ryhming nomogram computer programme. All subjects started at a work load of 100W at 50 pedal revs per min. This was increased by 25W at 1 min intervals to 200W max on the fourth minute, the fifth and sixth minutes of work were observed for a 'steady state' where the difference was not more than 5 bpm. This being achieved the maximum reading was taken and the test stopped. The information on heart rate and work were then processed by the cardiometer. If during the test any increase in load raised the heart rate past 150 bpm no further increases in load were made and the test continued for the full six minutes observing the test protocol as before (Åstrand and Rodahl, 1977). The mean value was between 130-160 bpm for all individuals who participated in the test.

To standardise the submaximal test ten subjects (5 aircrew and 5 physical training instructors) volunteered to participate in a submaximal direct measurement of oxygen uptake to compare with their indirect result. The exercise was performed on a Lanooy cycle ergometer adjusted for efficient pedalling. This electromagnetic device was used for the standardisation procedure only, in preference to the mechanical resistance Tunturi apparatus. The expired gases were collected and analysed for oxygen and carbon dioxide using a paramagnetic oxygen analyser and an infra-red CO_2 analyser respectively. Each unit was connected to a 4-channel pen recorder. These records permit the relationship, heart rate to oxygen consumption, to be calculated by the linear curve and hence its regression equation. The system is calibrated by passing a known

gas mixture through a wet gas meter (A. Wright and Co.) to give a constant reading. The work loads for the exercise are increased progressively from 30W by 20W increments for a period of 12 min. As in the indirect method the Åstrand age correction factor was used to give the final measured VO_2 max.

RESULTS

As would be expected in two very active squadrons the average age was around 30 years (30.71 ± 5.53). Therefore inherent fitness would be a major factor and is the reason for, in general, a very acceptable level of fitness, as only very healthy young men are originally selected for aircrew duties.

Maximum oxygen consumption of the aircrew at $46.5 \pm 9.05 \text{ ml.kg}^{-1}.\text{min}^{-1}$ body weight shows a good level of cardiovascular function particularly when considering a 1.5 mile run in 12 min equates to approximately only $40 \text{ ml.kg}^{-1}.\text{min}^{-1}$. A paired t-test was done on the group results from the predicted and directly measured ergometer tests but no significant difference was found (level of significance $p < 0.05$). The mean weight of the total group at $77.43 \text{ kg} \pm 9.83 \text{ kg}$ does not indicate a large number of overweight personnel. A clearer indication of this level of healthy weight is the group mean % deviation from normal desirable weight indices represented in Table I of $3.46 \pm 6.7\%$.

An influence of the sedentary nature of their occupation both on the ground and in the air is shown by the total skinfold mean $46.6 \pm 11.71 \text{ mm}$. With reference to Durnin and Womersley this revealed a body fat mean of $19.12 \pm 3.65\%$. When analysed for the % deviation from normal desirable fat indices represented in Table I the results demonstrate the problem $30.81 \pm 21.26\%$. In the past use of the standard weight scales to identify overweight has obscured the problem of overfat. This study clearly delineates between the two factors and in showing the groups' average weight to be inside the minimal percentage normally regarded as obese i.e. 10%, the problem is clearly overfat. Emphasis should therefore be on exercise with reference to diet only where overweight is defined as an additional problem. Regression analysis using a linear equation was carried out on lean body mass (LBM) and aerobic efficiency and the ponderal index and VO_2 max of the group. The relationship between lean body mass (LBM) and aerobic function was highly significant ($p = .01$). Similarly a highly significant relationship was identified between the ponderal index (WT/HT^2) and VO_2 max of the group ($p = .01$).

The systolic blood pressure for the group was $129.25 \pm 10.84 \text{ mmHg}$ and diastolic pressure $80.67 \pm 9.90 \text{ mmHg}$. Less than 2% of the group had pressure readings which would be considered outside normal limits.

TABLE I

Desirable fitness indices indicated by aerobic power and fat percentage in men of various weight groups.

Male (years)	Aerobic Power (ml/kg)	Fat (%)	153 60		50		112 54		120 59		130	
			Height cm	ins	Small frame Weight kg	lbs	Medium frame Weight kg	lbs	Large frame Weight kg	lbs		
18-29	43	13	153	60	50	112	54	120	59	130		
			155	61	52	116	56	123	61	134		
			158	62	54	119	58	127	52	137		
			160	63	56	122	59	130	64	140		
30-39	42	16	163	64	57	125	60	133	65	144		
			165	65	59	129	62	136	67	147		
			168	66	60	133	64	140	69	152		
			170	67	62	137	66	145	71	157		
40-49	40	18	173	68	64	141	68	149	73	161		
			175	69	66	145	70	153	75	165		
			178	70	67	149	72	158	77	169		
			180	71	69	153	74	162	79	174		
50-59	37	39	183	72	71	157	76	165	81	179		
			185	73	73	161	78	171	83	184		
			188	74	75	165	80	176	85	188		
			190	75	77	170	82	181	88	193		
60-69	34	20	193	76	79	174	84	185	90	197		

Aerobic power — Thompson (1977, VO_2 180) (Ref. Keren et al, 1980)

Fat — Durnin and Womersley (1974).

Weight — Metropolitan Life Insurance Co. (1959).

The health status of the group as evaluated by the questionnaire gave a below average risk status of 12.67 ± 3.33 . The groups disposition to exercise (at least once per week — pulse more than 120 bpm) was not high at only 51.2%. Smokers among the group, although in the minority, were still high at 24.39%. These two factors were the main cause of individuals being in the 'below average' and 'average' risk categories rather than 'Low Risk'.

Table II identifies a number of trends which are well established in literature with respect to many groups of subjects in various occupations. Notably agreement with studies which showed maximum oxygen consumption generally decreased with age. The same is true of the increase in body fat over age.

DISCUSSION

The fitness profile has identified many of the fitness and health characteristics in a group of aircrew personnel. All aircrew are thoroughly screened medically before initial engagement into the Air Force, and this is reflected in the low level of factors which might degrade their health status. Most problems in health risk are thus

TABLE II

Means and standard deviations of all variables.

Variable	Total Group (n = 82)	Ages 20-29 (n = 38)	Ages 30-39 (n = 39)	Ages 40-49 (n = 5)
Age (years)	30.71 ± 5.53	25.84 ± 1.79	33.94 ± 2.57	43.2 ± 1.93
Weight (kg)	77.43 ± 9.83	77.52 ± 10.44	77.16 ± 9.72	78.8 ± 4.01
Weight (Dev)* (%)	3.46 ± 6.7	3.26 ± 7.17	3.51 ± 6.35	4.68 ± 5.42
Height (cm)	180.42 ± 5.72	180.97 ± 5.06	179.84 ± 6.11	180.8 ± 6.76
Skinfolds (mm)	44.6 ± 11.71	44.78 ± 11.73	47.92 ± 11	50 ± 8.1
Body fat (%)	19.125 ± 3.63	17.23 ± 3.26	20.85 ± 4.75	24.26 ± 2.11
Fat (Dev)* (%)	30.81 ± 21.26	32.47 ± 24.98	27.75 ± 19.25	34.61 ± 11.51
Systolic bp (mmHg)	129.25 ± 10.84	129.68 ± 11.35	127.51 ± 9.99	133.8 ± 8.56
Diastole bp (mmHg)	80.67 ± 9.9	77.44 ± 10.36	83.07 ± 8.87	86.4 ± 4.75
Health Status	12.67 ± 3.34	11.18 ± 3.11	13.79 ± 3.00	15.2 ± 2.31
Active Exercise	51.21%	55.26%	53.84%	40%
Smokers	24.39%	15.78%	35.89%	NIL
Max Oxygen Uptake ($\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$)	46.5 ± 9.05	49.64 ± 9.05	44.76 ± 8.22	36.05 ± 4.01

self initiated individually, namely:— smoking, fat, minimal exercise and inability to modify stress. Answers to questions on alcohol intake were discounted as they often tended to be inaccurate. Each of these factors is influenced by some or all of the others, thus an evaluation of an individual's 'strengths' and 'weaknesses' enables him to understand and therefore modify his problem, improving his 'energy' potential. The concept of 'energy' identified by Lager (1974) consists of both physiological and mental components and found to be of high validity as a pilot reliability prediction.

Aircrew identified in this study as having lower than desirable aerobic indices, in the majority of such cases would improve simply by reducing their body mass, in the first instance by decreasing their free fat mass. The deviation of weight from desirable norms is not significant $3.46 \pm 6.7\%$ but the level of fat is high $30.81 \pm 21.26\%$. However the fitness tests highlight both the

high level of white fibre with its resultant effect on aerobic power and the overall poor muscle tone due to a reduced level of red muscle fibre. This indicates the additional need for a training programme to increase their lean muscle mass.

In general the main problem for aircrew is the sedentary nature of their job potentiating a lack of muscle tone and increase in body fat. A simple programme of calisthenics would greatly improve this situation and do much to relieve the prevalent back and neck strain due to poor flexion and mobility. Klein et al (1977) suggested there might be little advantage from fitness in tolerance to + G² physiologically but our indications are that better physical fitness would enhance mechanical efficiency of the individual and alleviate these problems. Obviously this would necessitate a programme of carefully graded exercises and not a punitive regime!

CONCLUSION

An individual approach to aircrew fitness by the Physical Educationist can identify individual characteristics, and therefore personalise the remedy. The dangers of a

general approach could be ineffective for two reasons, the prescribed remedy might be too little for some, too much for others and in both cases fail to satisfy specific needs. The relationship of fitness, health and tolerance to stress within the context of the people studied in this paper has shown that fitness and health of aircrew can be evaluated in a meaningful way. This has the result that the individuals being evaluated can be educated physically, and hence appreciate that personal responsibility for maintaining health and fitness, satisfactory for their specific needs, lies within themselves. This can be achieved by the introduction of a programme to increase physical fitness. This would need to include both graded exercises to increase lean muscle mass and guidance to decrease free fat mass.

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BOOK REVIEW

Title: THE RUNNER: ENERGY AND ENDURANCE
Authors: E. A. Newsholme and A. R. Leech
Publisher: Fitness Books, 21 Pitts Road, Oxford
Price: £6.95 + 55p P & P

Whenever one picks up a book by an author whom one knows, or knows of, there is inevitably a degree of expectation as to its merit. Eric Newsholme, co-author with Tony Leech, of this book, which should perhaps be subtitled "A runner's guide to the biochemistry of exercise", is one of the leading figures in the study of the regulation of metabolism; he also happens to be very experienced, even if not very fast, marathon runner. In recent years, he has been a regular guest speaker at symposia on the physiology and biochemistry of exercise, where his contributions have been marked by their clarity and authority. These qualities have been admirably applied to this book, which presents a state-of-the-art guide to thinking in the field of exercise biochemistry.

The Publisher's material recommends the book to coaches, runners and the intelligent laymen. To that list could be added all those subscribers to this Journal who do not fall into one of the categories mentioned. The greater part of the book is, as one would expect from these authors, devoted to the biochemistry rather than to the physiology of exercise and it is precisely for this reason that it is so welcome. There are scores, if not actually hundreds, of texts on the physiology of exercise available at all levels, from the elementary to the advanced. The average student, however, encounters more conceptual problems in the study of biochemistry than in physiology, and yet no textbook is available to guide him through these difficulties. This little book outlines the main aspects of physiology and biochemistry as they relate to exercise in general and to running in particular.

The text is clearly written and supplemented with excellent illustrations drawn by Dr. Leech. The presentation assumes that the reader has only a minimal knowledge of the life sciences and yet, even those areas which most undergraduate and many postgraduate students find difficult, are explained in a clear and concise manner.

In view of the present trend for mass-participation in endurance events, particularly marathon running, an understanding of the biochemical responses to endurance training and to acute exercise is essential. This is true, not only for those actively involved as participants, but also for those responsible for all aspects of the medical supervision of these competitors. Although coverage of many topics is necessarily superficial, anyone reading and understanding this volume should carry away sufficient information to form the basis for more advanced study.

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