EVALUATION OF PHYSICAL EFFICIENCY BY PULSE COUNT AFTER SUBMAXIMAL EXERCISE

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ABSTRACT

The paper gives the results of investigation conducted in the Defence Science Laboratory to test the consistency, repetitive and discriminatory value of the D.S.L. E.T. Scores as compared to the pulse counts for one minute, taken ½′ after 'Baithak' exercise at 40 cycles per minute extending over ¾′ to 2′. The duration of the exercise decreases as the age increases. The results show that the variation of the simple pulse counts is considerably smaller than that of the D.S.L. Scores. In view of this finding it has been suggested that the Armed Forces may be classified for physical efficiency on the basis of pulse counts taken after 'Baithak' exercise. The classification suggested consists of five grades of pulse counts. These are 80—90, 91—100, 101—110, 111—120 and greater than 120. The classification is done after adjusting the pulse count to 2′ exercise. The adjustment works out to be 5 beats per minute for every 15 seconds decrease in the exercise.

Introduction

Mookerjee *et al* (1952) and (1954) have suggested that cardiovascular efficiency, the major factor of physical fitness, can be assessed by D.S.L. Exercise Tolerance Test. The test consists in making the subjects to perform 'baithak' at 40 cycles per minute. The authors have pointed out that the greatest source of error in the above test is a wide range of uncertainty associated with the determination of the endurance time which is influenced by the motivation of the subject. The subject may stop the exercise before he is really exhausted. Another handicap of the test is the risk involved in taking a severe physical exercise by persons of the higher age group. Majumdar and Ramaswami (1955) have shown that the D.S.L. E.T. scores for maximum exercise can be estimated from ½ to 1½ minutes or 1 to 1½ minutes pulse counts after submaximal 'baithak' exercise for the durations ¼ to ½ minute and ¾ to 2 minutes. This paper gives results of the investigations carried out at the Defence Science Laboratory to examine the consistency, discriminatory and repetitive value of the D.S.L. E.T. scores calculated by Ramaswamy and Majumdar's formulae as compared to those of simple pulse counts after various submaximal exercises.

Details of Experiment

From the age groups 17—25 yrs., 26—35 yrs., 36—40 yrs., 41—45 years and 46—50 years ten subjects each were taken and the subjects were asked to do two exercises, the duration of which is given in Table I. Before commencing the experiment a complete clinical examination was done in each case to

exclude those who were unfit to carry out the test. Each individual was then made to do 'baithak' as described by Mookerjee and Majumdar (1952). The rhythm of the exercise was maintained with a metronome or a pendulum 22" long, the frequency of oscillation being 40 per minute. Each subject had to perform the first exercise for the period applicable to his age after which he was made to sit on a chair. Exactly half a minute after completion of the exercise, the number of heart beats was counted by strethescope for $\frac{1}{2}$ to 1 minute and 1 to $1\frac{1}{2}$ minutes. The subjects were then given rest for one hour and were made to do the second exercise for the duration applicable to their age. Heart beats were taken for $\frac{1}{2}$ to 1 minute and 1 to $1\frac{1}{2}$ minutes after this exercise also. These readings were taken for each subject at weekly intervals for six weeks.

TABLE I

Age group	Duration of 1st exercise	Duration of 2nd exercise	Remarks
17—25	$\frac{1}{2}'$	2′	Recruits combatants.
26—35	$\frac{1}{2}'$	$1\frac{3}{4}'$	Do.
26—35	$\frac{1}{2}'$	$1\frac{3}{4}'$	Officers.
35—40	$\frac{1}{2}'$	$1\frac{1}{2}'$	Do.
41—45	$\frac{1}{2}'$	1′	Do.
46—50	$\frac{1}{2}'$	$\frac{3}{4}'$	Do.
41—55	$\frac{1}{2}'$	$\frac{1}{2}'$	Do.

Results of Statistical Analysis

D.S.L. E.T. scores were calculated by the formulae given by Majumdar and Ramaswamy for the pulse counts 1 to $1\frac{1}{2}$ minutes and $\frac{1}{2}$ to $1\frac{1}{2}$ minutes after the two exercises in each group. Calculations were also made for the pulse counts $\frac{1}{2}$ to 1 minute by using the formula for 1 to $1\frac{1}{2}$ minutes. The calculated D.S.L. scores and the pulse counts are summarised in Tables II, III and IV.

Table II shows the average pulse counts with its standard error for basal pulse, pulse counts after the 1st and 2nd sub-maximal exercises, and the estimated D.S.L. scores. This table leads to the following conclusions.

(*a*) The average basal pulse counts for half a minute varied from 33·8 to 41·2.

(*b*) The average pulse count after the 1st and 2nd exercise varied from 68·5 to 90 and 91 to 108·5 per minute respectively. It was maximum for the age groups 17 to 25 and 36 to 40 and was significantly more than for the other age groups.

(*c*) The D.S.L. scores estimated for ½ to 1 minute, 1 to 1½ minutes and ½ to 1½ minutes pulse counts after the different exercises differed to a considerable extent; and this showed the limitations of the estimated D.S.L. scores.

(*d*) The standard errors of the averages for pulse counts were considerably less than those for the D.S.L. scores. This evidently shows that assessment of physical efficiency based on pulse counts may be more reliable than the D.S.L. scores.

Table III gives the co-efficient of variation evaluated from the residual error, the error in the mean for individuals and the error in the mean for weeks for both the estimated D.S.L. scores and pulse counts. This table indicates that:—

(*a*) The percentage of variation in the residual error for D.S.L. scores varied from 13 to 34, while for the pulse counts it was 3·8 to 7 only.

(*b*) The variation between the mean of individuals for D.S.L. scores was 13·0 to 26% while for pulse counts it was 5 to 17.

(*c*) The variation between the weekly means for D.S.L. scores was 4 to 14% while for pulse counts it was 1 to 5.

From the above it follows that the variation of the estimated D.S.L. scores was much higher than the pulse counts for individuals and within the individuals.

Table IV gives the ratio of variances for the mean sum of squares between individuals and uncontrolled causes. This gives us the discriminatory value of the D.S.L. scores and the pulse counts to differentiate between individuals. If the ratio is high, the discriminatory power is high. Adjudged from this point of view the table shows that for D.S.L. scores, this ratio varied from 3 to 17 for individuals, while for pulse this was 10 to 92, barring one single exception, and was maximum after the second sub-maximal exercise. This shows that the discriminatory value between individuals was much higher for the pulse counts for the duration ½′ to 1½′ after the second sub-maximal exercise.

The above findings may be summarised as follows:—

(*a*) The percentage error of the D.S.L. values was considerably higher than for the pulse counts. The calculation of the D.S.L. scores by the formulae given by Majumdar and Ramaswamy increased the error to a considerable extent and therefore the scores was much less reliable than the pulse counts after sub-maximal exercises.

(*b*) This discriminatory power of the D.S.L. scores to differentiate between individuals was far less than the pulse counts after sub-maximal exercises.

TABLE II

Average Pulse Count and Estimated D.S.L. Scores

Age Group	Basal Pulse	Pulse Counts						D.S.L. Scores		
		½′—1′		1′—1½′		½′—1½′		½′—1′	1′—1½′	½′—1½′
		Ist exercise	IInd exercise	Ist exercise	IInd exercise	Ist exercise	IInd exercise			
17—25 yrs.	38·45±0·29	44·48±0·34	57·02±0·45	38·00±0·45	50·33±0·44	82·40±0·45	107·36±0·75	75·43±3·93	90·90±3·83	100·45±4·36
26—35 yrs.	34·50±0·40	40·93±0·31	54·57±0·31	34·48±0·25	49·64±0·48	75·40±0·50	104·21±0·60	60·88±1·38	71·67±2·00	78·38±1·53
36—40 yrs.	33·77±0·26	44·73±0·45	57·63±0·32	37·55±0·45	50·83±0·48	81·47±0·71	108·47±0·63	45·13±1·46	57·03±1·55	62·37±1·98
41—45 yrs.	37·33±0·33	40·06±0·54	52·83±0·62	34·28±0·56	48·00±0·47	74·33±0·72	100·83±0·61	41·06±1·90	47·44±1·46	52·22±1·91
46—50 yrs.	41·17±0·75	44·83±1·26	50·17±1·08	39·33±0·99	45·50±0·88	84·17±1·81	95·67±1·87	53·83±7·35	53·00±6·72	56·33±9·42

TABLE III

Co-efficient of Variation for Pulse Count and Estimated D.S.L. Scores

Age Description of subjects.						
					17—25 yrs.	26—35 yrs.
Basal pulse count		Weeks	2.02	3.22	3.07	7.12
		Individuals.	3.85	3.77	7.61	7.02
		Error.	4.84	7.45	4.32	3.75
Pulse Counts	½′ — 1′	Weeks.	1.45	2.75	2.29	5.32
	1st exercise	Individuals.	10.43	6.38	12.63	7.34
		Error.	4.88	4.86	4.45	5.69
	½′ — 1′	Weeks.	3.29	3.29	5.12	3.71
	2nd exercise	Individuals.	11.26	7.57	4.79	12.34
		Error.	6.11	4·99	6.60	6.91
	1′ — 1½′	Weeks.	2.36	2.51	3.13	4.47
	1st exercise	Individuals.	10.38	6.45	9.02	9.22
		Error.	3.57	4.27	4.74	4.13
	1′ — 1½′	Weeks.	2.25	2.42	1.60	4.12
	2nd exercise	Individuals.	13.89	6.38	12.39	4.73
		Error.	5.16	3.70	3.00	4.98
	½′ — 1½′	Weeks.	2.34	1.14	2.81	1.76
	1st exercise	Individuals.	17.44	8.26	12.77	9.38
		Error.	5.62	6.29	5.17	4.19
	½′ — 1½′	Weeks.	1.19	1.61	2.08	1.72
	2nd exercise	Individuals.	15.25	7.23	12.52	6.83
		Error.	4.55	3.74	3.18	2.55
D.S.L. Score	½′ — 1′	Weeks.	10.98	6·13	9.53	14.05
		Individuals.	25.48	22.90	26.30	13.42
		Error.	33.79	14.76	17.75	19·68
	1′ — 1½′	Weeks.	8.36	3.92	9.43	12.42
		Individuals.	22.56	17.51	23.41	15.83
		Error.	27.28	18.08	14.89	13.05
	½′ — 1½′	Weeks.	6.44	4.31	9.03	13.25
		Individuals.	24.97	21.20	25.24	15.59
		Error.	27.47	12.65	17.41	15.55

41—45 yrs.	46—50 yrs.
7.12	4.44
7.02	
3.75	
5.32	6.38
7.34	
5.69	
3.71	6.15
12.34	
6.91	
4.47	5.29
9.22	
4.13	
4.12	5.26
4.73	
4.98	
1.76	4.77
9.38	
4.19	
1.72	4.80
6.83	
2.55	
14.05	33.44
13.42	
19·68	
12.42	31.08
15.83	
13.05	
13.25	40.97
15.59	
15.55	

TABLE IV

Ratio of Variance between Individuals and error due to uncontrolled causes 'F' Test

Age Group	Basal Pulse	Pulse Counts						D.S.L. Scores		
		½′—1′		1′—1½′		½′—1½′		½′—1′	1′—1½′	½′—1½′
		Ist exercise	IInd exercise	Ist exercise	IInd exercise	Ist exercise	IInd exercise			
17—25 yrs.	3·80	27·46	43·52	20·44	57·61	50·77	67·15	3·41	4·10	4·96
23—35 yrs.	1·53	10·31	18·07	13·81	10·35	13·65	22·36	14·57	5·62	15·85
36—40 yrs.	18·53	32·08	102·32	3·13	36·46	21·79	92·70	13·17	14·85	12·60
41—45 yrs.	20·90	9·90	5·39	19·14	30·15	29·82	43·13	2·79	8·83	6·43

Proposed Method of Classification for Physical Fitness

The results of the present investigations show that the D.S.L. E.T. scores, whether actual or estimated, are subject to considerable variation of 13% to 34% while the variation in the pulse counts is of the order of 3·8% to 7% only. It is also seen that the discriminatory power of the simple pulse counts after the sub-maximal exercise extending $\frac{3}{4}$ to 2 minute is more than that fo the D.S.L. scores. In view of these findings it is reasonable to conclude that physical efficiency may be assessed from the simple $\frac{1}{2}$ to $1\frac{1}{2}$ minutes pulse counts after sub-maximal exercise. It is possible to classify the subjects of different age groups in-to four grades, say I, II, III and IV, according to their expected physical performance on the basis of $\frac{1}{2}$ to $1\frac{1}{2}$ minutes pulse counts after $\frac{3}{4}$ to 2 minutes sub-maximal exercise. The grades for the different age groups have been worked out as follows:—

Grades	Mean Pulse Count
I	Mean for the age group minus 4 S.D.
II	Mean for the age group − 2 S.D.
III	Mean for the age group
IV	Mean for the age group + 2 S.D.

The difference between the maximum and the minimum values for each of the grades is twice the standard deviation. Using this criterion $\frac{1}{2}$ to $1\frac{1}{2}$ minutes pulse counts for different age groups have been worked out and shown in Table V.

TABLE V

Pulse Counts for Different Age Groups

Age Group	Exercise	Grades			
		I	II	III	IV
	Secs				
17—25	120	80—90	91—100	101—110	111—120
26—35	105	90—100	101—110	111—120	121—130
36—40	90	95—105	106—115	116—125	126—135
41—45	60	Same as for 36—40 age group.			
46—50	45	Same as for 36—40 age group.			

Persons with pulse counts higher than that given for grade IV should be considered to have poor physical efficiency.

From the practical point of view it is highly desirable and convenient if grading can be done irrespective of age. This can be done by using the pulse counts grades given in Table V for 17—25 for all the age groups after making the necessary correction for the shortage in the duration of the exercise. The grading of a subject can be done by obtaining $\frac{1}{2}'$ to $1\frac{1}{2}'$ pulse counts adjusted for two minutes exercise. This adjustment works out to be approximately 5 beats per minute for every 15 seconds of exercise and represents the average rise in the pulse counts for subjects belonging to different age groups for 15 seconds of exercise near the submaximal period prescribed for the different age groups. This correction serves as a fairly satisfactory method for bringing the pulse count of subjects of different age groups to the same submaximal exercise of 2 minutes. Thus for the age group 17—25, the grading can be done with the $\frac{1}{2}'$ to $1\frac{1}{2}'$ pulse count for 2 minutes exercise. For the age group 26—35, 5 is added to the $\frac{1}{2}'$ to $1\frac{1}{2}'$ count after 105 seconds exercise and the grading is done on the basis of the pulse count adjusted for 2 minutes exercise. For the age group 36—40 the observed $\frac{1}{2}'$ to $1\frac{1}{2}'$ pulse count after 90 seconds exercise is increased by 10 to adjust it for 2 minutes exercise. A similar procedure is adopted for the higher age groups.

Practical application of the test—The subjects to be tested are examined clinically to rule out any condition which may contraindicate the exercise involved in the test. He is then asked to do 'Baithak' exercise for the period applicable to his age. After the completion of the exercise he is made to sit on a chair and exactly $\frac{1}{2}$ minute after stopping the exercise, heart beats are counted for 1 minute.

In age group 17—25 for 2 minutes exercise grading is done according to the following schedule:

Grade I	Pulse count	80—90
Grade II	,, ...	91—100
Grade III	,, ...	101—110
Grade IV	,, ...	111—120
Grade V	,, ...	Above 120

For higher age groups, for each reduction of 15 seconds exercise 5 is added to the recorded pulse count to bring it to the level of 2 minutes exercise and grading will be then ascertained on the basis of above schedule.

Discussion and Conclusion

It will be seen that the method suggested in this paper for assessing physical efficiency is simple and can be undertaken anywhere in the field without any special equipment. Results can be judged by pulse count direct without any calculations. As the test requires the subject to undertake one submaximal exercise only for the duration suitable for his age, it is hoped that error creeping in due to motivation factor will be eliminated. The test is more reliable as regards consistency and discriminatory value than that proposed by Mookerjee, Majumdar and Ramaswamy.

The proposed test can be adopted by the Armed Forces for classifying persons in to different categories of physical efficiency which will be helpful in recruitment and allotment of duties of enrolled persons of different age groups. It may, however, be noted that reliability of the test should be confirmed by correlating the classifications made by the above test with actual performance of the subjects.

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