20-MST and PWC₁₇₀ validity in non-Caucasian children in the UK

Craig Mahoney

Health and Physical Education, The Queen's University of Belfast, Belfast, UK

The validity was investigated of 20-MST (20 Metre Endurance Shuttle Run Test) and PWC₁₇₀ (Physical Working Capacity) field tests with laboratory-measured peak oxygen uptake ($\dot{V}O_{2\text{peak}}$) in a multiracial UK population of 12-year olds: 103 subjects completed the 20-MST and 96 of these completed the PWC₁₇₀. To assess validity, a laboratory treadmill test was completed by ten boys and ten girls who had performed both field tests. $\dot{V}O_{2\text{peak}}$ was $43.8 \text{ ml kg}^{-1} \text{ min}^{-1}$ for boys and $38.5 \text{ ml kg}^{-1} \text{ min}^{-1}$ for girls. Pearson product-moment correlation showed 20-MST to be a reliable measure of cardiorespiratory fitness ($r=0.83$, boys; $r=0.76$, girls, $P<0.03$), while correlations with PWC₁₇₀ were lower ($r=0.64$, boys; $r=0.54$, girls) and not significant. The 20-MST was consistent in retest ($n=20$) - reliability coefficients $r=0.73$, boys; $r=0.88$, girls; $P<0.01$. The results suggest 20-MST is a valid, measure of fitness in this population when compared with $\dot{V}O_{2\text{peak}}$. PWC₁₇₀ is less valid, possibly due to cultural and social backgrounds. The cycle test was inappropriate in this population, especially for girls unaccustomed to exercise and cycling. The 20-MST test is recommended for large groups of children when facilities are limited. It requires limited skill or habituation and is relatively non-invasive.

Keywords: Eurofit, 20-MST, PWC₁₇₀, fitness, endurance, non-Caucasian children

The use of field tests to assess cardiorespiratory fitness is not new, but a valid and reliable test which is easy to administer, uses incremental workloads, incorporates pacing and provides objective information appropriate for different populations has not been identified. Field tests must be reliable and valid, allow relatively large numbers to be assessed simultaneously, require limited equipment and be non-invasive.

Field tests emulating laboratory protocols produce the greatest agreement with $\dot{V}O_{2\text{max}}$. Van Mechelen *et al.*¹ suggests much of the variation between field and laboratory tests is due to subject motivation and pacing ability. The test surface, climate, prevailing weather and age and sex of the subjects may have some effect, in addition to Hawthorne effects from subject-tester interaction.

The 20 Metre Endurance Shuttle Run Test (20-MST) was designed by Leger and Lambert² to be completed indoors using workloads (speed) lasting approximately 1 min ('paliers'). The test starts at 8.0 km h^{-1} and increases 0.5 km h^{-1} every palier. A sequential lap scoring technique is used. Subjects run to exhaustion while maintaining cadence, i.e. reaching the end of the 20-m course in unison with the tape signal. Audio signals are emitted from a prerecorded tape controlling running speed. The 20-m course is run on a variety of surfaces with a continuous multistage protocol.

Several studies of 20-MST with Caucasian populations have demonstrated its high validity compared with laboratory $\dot{V}O_{2\text{max}}$ tests. Correlation coefficients of $r=0.76$, $r=0.93$, $r=0.71$, $r=0.46$ and $r=0.87$ have been produced with Caucasian children and adults^{1,3-6}. The test seems to be a good predictor of maximal aerobic capacity in these populations.

Field tests have been criticized⁷⁻⁹ for inaccuracy, motivation problems, variation with age and gender and difficulties of interpretation. However in schools they provide a method of monitoring children's fitness. They can be used to teach health-related fitness and prompt discussion of health and activity. They also offer opportunities for cross-curricular teaching in science, mathematics and technology.

This study investigated the validity of 20-MST and PWC₁₇₀ (Physical Working Capacity) field tests as measures of aerobic fitness in a UK inner city population of non-Caucasian children. The reliability of the 20-MST was investigated. The feasibility of using such field tests in a non-Caucasian population and acquisition of data relating to fitness in the population were also investigated.

Methods

A total of 103 healthy, non-Caucasian children aged 12 years at an inner city UK school were tested during 1 month. The population included Indian, Afro-Caribbean and mixed races. A few white children took part but accounted for less than 5% of the sample (reflecting the school population). Height, weight and skinfold measures (bicep, tricep, subscapular and suprailiac, right side of the body) were measured at the initial visit and a short lifestyle questionnaire based on one given to German children¹⁰ was completed.

Address for correspondence: Mr C. Mahoney, Health and Physical Education, The Queen's University of Belfast, Botanic Park, Belfast BT9 5EX, UK

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The 20-MST was completed according to Eurofit¹¹, though the actual test was produced by The Queen's University of Belfast. The tape recorder and tape were checked before each session for timing accuracy¹². A 20-m course with 1-m clearance marked by plastic tape and cones was set up in the school gymnasium. In each sample, 15–20 students were tested, boys and girls separately. Gender segregation was common in physical education at the school to preserve racial self-esteem and maintain social customs. The 20-MST ended voluntarily or by removal if running speed could not be maintained (inability to reach the 20-m mark twice in succession coincident with the tape signal). The number of laps completed was the fitness score for each subject.

A Monark drop weight cycle (Monark, Sweden) was used to assess physical working capacity (PWC₁₇₀) as described by Eurofit¹¹. The most ergonomically efficient position was provided for each subject by adjustment of seat and handlebars before habituation. Initial workloads were calculated on the basis of 1 W kg⁻¹ body weight for boys, and 0.75 or 0.5 W kg⁻¹ body weight for girls, the lower weight used for girls less accustomed to exercise. Successive workloads were calculated from the consequent heart rate response of the previous workload. Each workload lasted 2 min. Heart rate was monitored using a Polar Electro PE3000 heart rate receiver (Polar Electro, Finland). Heart rates >155 beats per minute from workload 1 or >165 beats per minute from workload 2 were used to end the test early. At the end of workload 3, heart rates >150 beats per minute required completion of a fourth workload. Increments were made in accordance with Eurofit¹¹.

To validate the 20-MST and PWC₁₇₀, 20 children (ten girls and ten boys) completed a laboratory test of peak oxygen uptake ($\dot{V}O_{2peak}$). Using a Powerjog treadmill (Sport Engineering, UK) incorporating an incremental protocol with continuous heart rate monitoring on a cardiometer (Cardiac Recorders, UK), CR7 and on-line gas analysis from a Mijnhardt Oxycon automated gas analyser (Mijnhardt BV, Holland), $\dot{V}O_{2peak}$ was measured. Before testing, subjects were habituated and shown starting and stopping procedures.

Results from the lifestyle questionnaire were used to determine the laboratory protocol. Owing to the girls' sedentary lifestyle a Balke test walking protocol was used. This started at 4.8 km h⁻¹ and 0% gradient with 5% gradient increases every 2 min. The boys completed a jogging protocol starting at 8.0 km h⁻¹ and increasing to 9.4 km h⁻¹ followed by 5% gradient increases every 2 min to exhaustion. The treadmill test ended at voluntary exhaustion or attainment of British Association of Sports Sciences (BASS)¹³ guidelines.

A subsample ($n=20$) of the population was retested with 20-MST to assess reliability.

Results

The population (53 boys, 50 girls) were all 12 years old and attending a UK multiracial inner city school.

Table 1 outlines their racial origins. The anthropometric measures in Table 2 are consistent with those of

Table 1. Percentages of children of different racial backgrounds used in the study

Racial background	Boys	Girls
Indian	83	70
Afro-Caribbean	8	22
Mixed	7	4
White	2	4

Table 2. Means(s.d.) values for anthropometric data

	Boys ($n=53$)	Girls ($n=50$)
Height (cm)	152.5(8.6)	153.8(7.3)
Weight (kg)	41.9(9.7)	45.9(9.9)
Body fat (%)	19.9(6.2)	25.8(5.0)

* Based on equations of Durnin and Rahaman (1967)¹⁴

Table 3. Cardiorespiratory fitness results* for 20-MST, PWC₁₇₀ and peak $\dot{V}O_2$

	Boys		Girls	
	n		n	
20-MST (laps)	53	47.4(17.5)	50	31.3(12.8)
PWC ₁₇₀ (W kg ⁻¹)	53	1.97(0.46)	50	1.35(0.42)
$\dot{V}O_{2peak}$ (ml kg ⁻¹ min ⁻¹)	10	43.8(4.5)	8	38.5(4.4)

* Values are mean(s.d.)

Table 4. Correlation coefficients of peak $\dot{V}O_2$ versus 20-MST and PWC₁₇₀

	Boys		Girls	
	PWC ₁₇₀	$\dot{V}O_{2peak}$	PWC ₁₇₀	$\dot{V}O_{2peak}$
20-MST	0.54	0.83	0.18 n.s.	0.76
PWC ₁₇₀		0.64 n.s.		0.54 n.s.

n.s., not significant

other studies^{6,10,15} of children living in a western culture. The cardiorespiratory fitness results in Table 3 are also consistent with these studies.

Twenty children (12 boys, 8 girls) completed a test-retest study on the reliability of 20-MST. High test-retest reliability coefficients were achieved for girls ($r=0.88$) and boys ($r=0.73$). Both results were highly significant ($P < 0.008$) suggesting the 20-MST is reliable for use with multiracial children.

The correlation matrix for aerobic endurance results is provided in Table 4. The correlation between $\dot{V}O_{2peak}$ and 20-MST is high for boys ($r=0.83$) and girls ($r=0.76$), and is significant ($P < 0.03$). All other correlations show no significance relationships between tests. This was particularly apparent for girls where the correlation between PWC₁₇₀ and 20-MST is poor ($r=0.18$).

A summary of the lifestyle questionnaire is provided in Table 5. Only 20% of girls played organized sport compared with 42% of boys. Housework was done by 55% of girls but only 20% of boys.

Table 5. Lifestyle questionnaire findings expressed as percentages

	Boys (n=50)	Girls (n=53)
Transport to school		
Walk	34	31
Car	6	8
Bus	60	61
Play organized sport	42	20
More than 3 h television/day	40	61
Extra classes outside school	10	10
Completes homework	92	86
Completes housework	20	55
Part-time job	10	10

Discussion

The multiracial population in this study provides some information on fitness of UK subcultures. The predominant Indian population may have biased the results. Wills¹⁶ showed that English children have higher cardiorespiratory fitness than their Indian counterparts, though a decline with age still prevails. Little information is available on the fitness of Indian girls possibly due to problems associated with motivation, their limited physical activity and their extensive home responsibilities.

The religious, cultural, linguistic and social traditions of many of the girls in this study preclude their being involved in physical activity, and consequently their ability and attitude to physical education may be different from other children. Participation in mixed physical education classes is uncommon, and girls must cover their legs at all times. The lifestyle questionnaire provided information on general physical ability and supported the notion that many of the girls never exercise. Many of the girls had never ridden a cycle and for the PWC₁₇₀ had difficulty pedalling at the required cadence. Considerable time was required for habituation and learning to cycle. This may have produced psychological variations including heart rate elevation from anxiety, and a lack of cycling efficiency may also have raised heart rates and affected correlation with $\dot{V}O_2$ values in girls.

Two of the girls were unable to finish the laboratory treadmill test of maximal aerobic capacity ($\dot{V}O_{2peak}$) and their results were discarded. The remaining ten boys and eight girls produced high validity scores for 20-MST ($r=0.83$, boys; $r=0.76$, girls; $P < 0.03$) when compared with $\dot{V}O_{2peak}$. The validity found for PWC₁₇₀ was $r=0.64$, boys; $r=0.54$, girls (not significant). There was no significant relationship between 20-MST and PWC₁₇₀ in either sex. The high correlations between the 20-MST and $\dot{V}O_{2peak}$ suggest greater than 70% of the variance for boys and 57% of that for girls can be explained by performance in the 20-MST. These are both higher than the values obtained by van Mechelen *et al.*¹, and support the use of 20-MST in assessing peak aerobic power in children.

In conclusion, the 20-MST is an ideal field test measure of cardiorespiratory fitness. It is progressive (the American College of Sports Medicine consider progressive workload tests safer than tests requiring the subject to judge time and speed), with workloads increasing every minute. Subjects are given explicit instructions. Running speed is predetermined by the cassette tape. The test can be completed indoors. The scoring method is easy to administer and interpret. The test has realistic endpoints. Motivation is partially controlled by the predetermined workloads and body weight is an integral part of the test.

The results suggest that 20-MST provides a valid and reliable field test of cardiorespiratory fitness for large-scale testing of mixed racial populations in the UK. The test is relatively non-invasive, requiring limited apparatus and little skill. The PWC₁₇₀ was found to be inappropriate for large-scale testing of such a population. It lacks validity, is more time consuming, requires particular skill and needs equipment and expertise often beyond the school budget.

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