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COMMITTEE FOR THE DEVELOPMENT OF SPORT

Committee of Experts on Sports Research

EUROFIT

Handbook for the EUROFIT Tests of Physical Fitness

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The drawings in Part II, Section 3 are by Ms Bea Albers, of the KU Leuven. The photographs in Part II, Section 2 are reproduced by courtesy of Mr Tuxworth.

1. WHY TEST PHYSICAL FITNESS? THE REASONS FOR EUROFIT

This handbook presents the outcome of several years' co-ordinated European research into a long-felt need: the identification, or development if necessary, of effective means of accurately assessing physical fitness in children, appropriate to school and survey use. A number of established tests and test "batteries" existed already. The projected development of other national tests, with its associated duplication of effort and dilution of resources was in itself a spur to the Committee for the Development of sport to encourage the research directors to build a complete European set and thus to contribute to that "greater unity amongst its members" which is the aim of the Council of Europe. Sport, physical education and health cross national boundaries: they use common tools, instruments and language. Physical fitness therefore lends itself to being assessed in the same way across Europe.

Three main reasons have inspired the creation of EUROFIT:

i. Physical fitness is an important component of health and of physical education

Physical education is one of the few subjects which all children are required to do at school. To be physically fit is not just a help to sport and physical education; it is also a major factor in leading a happier and fuller life. Even during its experimental phase, the EUROFIT tests have shown that they have many important uses:

- in a relatively short time they can yield a great deal of new, descriptive information on the basis of which attitudes and policies concerning the condition of children can be assessed, and if necessary, revised, often with implications for society as a whole;

- for the individual child, the measurement of fitness can help to develop a positive attitude to the body; can enable him or her to achieve a self-awareness of his or her physical state and thus become better motivated to maintain or improve his or her fitness; the tests can also encourage parents to become actively interested and involved in the status of their children's physical fitness (and even to improve their own);

- the tests may reveal individual or group deficiencies in health (whether as a result of a single survey or of monitoring changes over time through several surveys) and provide a basis for designing and evaluating possible remedies;

- with regard to sports participation, the tests may discover weaknesses in overall or specific aspects of fitness and thus may help to avoid sports injuries; on the other hand, they may reveal latent abilities which the child might wish to develop;

- the EUROFIT tests can also be modified for use with disabled children, including mentally handicapped children, and to help develop adapted physical activities for them.

The declining levels of average physical activity and exertion in the daily life of most children mean that sport and physical education are often the only forms of exercise which they have. Those studies carried out so far tend to show that levels of physical fitness could be improved and the risk of ill health - and particularly of cardio-vascular disease - decreased. On the other hand children nowadays have more opportunities and facilities for taking up active leisure-time pursuits than those available to thier parents. Measuring fitness and providing information and encouragement on how fitness may be improved can promote the use of those sport and recreation facilities provided at some cost by the member states to enrich the lives of their citizens.

ii. Assessment of physical fitness is of value to educators and children

While it has long been recognised as a potent attribute for enhancing the quality of life, physical fitness has suffered in the past from the difficulty of assessing its many components accurately and objectively. It has often been judged simply on the basis of results in games or competitions: "winners and losers". In contrast to such a performance-based judgment, the EUROFIT tests are sensitive, individual and reliable instruments for assessing its various principal dimensions (cardio-respiratory endurance, strength, muscular endurance and power, flexibility, speed, balance). They are simple to administer and take account of the normal school/class environment. In addition there is a further test which lends itself more to survey or project use.

The need for an overall objective assessment has been long felt by teachers, who, in the past thirty years, have only been able to use ad hoc tests. The provision of a common European set of tests will allow teachers and others to proceed with confidence in the scientific bases of the measures used, and to participate in a coherent European endeavour. Though the EUROFIT tests are designed primarily for school-aged children (6-18), they have also been used successfully with later age-groups, and can provide a stable point of reference in the difficult change from school child to adult.

iii. EUROFIT is a contribution to education

Understanding and acquiring physical fitness is only a part of physical education, which itself is an integral part of education in general. Physical fitness therefore is not the sole concern or responsibility of physical education teachers: it should be a common concern of children, parents, school interests and indeed, of all society. All those involved with health, sport and physical education, including of course principally physical education teachers, will have a direct interest in EUROFIT, but EUROFIT should and must go beyond the strict confines of the physical education lesson, and help reinforce the place of physical education in schools. The tests can contribute to the teaching of other science-based subjects and provide an important bridge with other disciplines such as human biology or computer studies. Some tests can be self-administered, while others rely on the help of classmates They are thus an educational tool in themselves, a way of learning and a road to self-knowledge.

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While EUROFIT is a reflection of best modern practice, no set of tests can be permanent: the set may therefore have to be changed in the light of new knowledge or experiences. One of the prime objectives of EUROFIT is to enable common data to be collected so that scientific conclusions can be drawn from them (eg, on possible health deficiences via population studies, the connections between sports participation and health) and for this strict conditions of administration are required. It is not, however, the purpose of EUROFIT to prepare a picture of physical fitness in European countries. The data to be collected could be used in this way but only in the context of scrupulous research. It is at national level that the data will be most useful, enabling policy-makers to take appropriate decisions in the light of solid evidence. Lastly, it should be stressed that EUROFIT cannot be an instrument for assessing the performance of physical education teachers. The fitness of children reflects their lifestyles as a whole, and not just their exercises in 2 or 3 hours of weekly physical education classes.

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Implementation

The EUROFIT tests are simple and practical; they are based on relevant, reliable and proven ones. This has always been one of the main concerns of the Sports Research Committee of the Council of Europe's Committee for the Development of Sport. EUROFIT is a

co-effective package whichever of the applications mentioned earlier it is used for, and whether carried out by physical education teachers in the class or by special mobile teams with laboratory-type equipment. A class can be administered in a reasonable time and at reasonable expense. They are suitable for any child taking part in normal physical education lessons. They provide immediate standardised data and can be used over a long period of time to detect status, changes and trends. It seems that no other existing combination of tests provides similarly useful and comprehensive data relevant to the whole range of physical fitness. It is thus important for the appropriate authorities responsible for education and for sport to facilitate and encourage its implementation with as many children as possible and to make the resources - not least time, personnel and training - available for this.

The test for cardio-respiratory endurance to be selected will vary according to the mode of use chosen. Each mode imposes constraints favouring, or enforcing, the selection of one or the other test. Thus for national survey purposes - where it is necessary to have accurate measures of a sample of individual children and where comparisons are sought with other groups (maybe including adults) - the bicycle ergometer test will be the one chosen. Similarly, when looking for a pedagogical application of the test experience to other disciplines, the bicycle ergometer test will again be chosen. By contrast when measuring cardio-respiratory endurance in a normal class situation, where large numbers of children are to be measured a short period, often with minimal resources, the multi-stage endurance shuttle run is the only feasible test.

Testing and strategies

As stated earlier, all those concerned with sport and physical education are directly interested in testing physical fitness, and will be particularly desirous of knowing the fitness levels of those entrusted to their charge, whether in physical education, school sports and games or in sports clubs. While physical education teachers will probably be the main instigators of testing, it must be stressed once again that it is not their sole concern. They should be supported by others, in the form of research teams attached to universities, education authorities or school medical or careers services. These bodies could oversee implementation, advise schools or sports clubs, train and help testers in the schools, and analyse the data at regional or national level. In addition, some form of central co-ordination and data collection body or agency will probably be needed to give guidance, and to provide the main impulse for recording and interpreting the data for national policy purposes.

One approach could be to adopt a three-fold strategy:

i. in the short term, to establish reference values on a national basis via the careful collection of data in controlled conditions (survey mode);

ii. in the long-term, to aim for a regular assessment (say once a year) of all children in schools, under the aegis of the physical education programme, thus allowing comparison with the national reference values (class mode);

iii. in the meantime, to encourage all EUROFIT testing programmes, even on a small-scale, national or regional, whether in surveys or in class.

Finally, it should be noted that the EUROFIT tests are proposed as a common basis: they are adequate for testing the physical fitness of children, but where a national test has been developed for testing another aspect of physical fitness, such a test may be added to the EUROFIT tests.

2. THE ORIGINS AND DEVELOPMENT OF EUROFIT

The need for testing physical fitness and establishing reference data for European school children was first recognised in 1977 at the meetings of the Directors of Sports Research Institutes, (the body which preceeded the Committee of Experts on Sports Research). The principle aims of this project were:

i. to establish a commonly agreed test battery in Europe;

ii. to help teachers in assessing the physical fitness of their pupils in schools;

iii. to help in measuring the health-related fitness of populations.

In order to realise these aims, a series of European research seminars on testing physical fitness was organised under the aegis of the Committee for the Development of Sport. (1).

The objective of the first seminar, which took place in the National Institute of Sport and Physical Education (INSEP) in Paris (October 1978), was to discuss the philosophy and to review the methods of investigating physical fitess in school children. The seminar was to determine, if possible, the factors which comprise such physical fitness; and having decided upon these fundamental factors, to see whether it might be possible to establish a common set of tests which might be used in each and every European country. The work of the seminar crystallised in agreement concerning the elements and basic dimensions of physical fitness as a necessary component of well-being, which were:

a. Structural factors: height, weight and body fat (with other physical characteristics, if possible);

b. Functional factors: cardio-respiratory endurance, muscular strength (static and dynamic) flexibility and speed (running and segmentary);

c. Co-ordination.

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(1) See Appendix III for a list of reports, publications, etc.

The second seminar was organised by the Department of Physical Education at the University of Birmingham in June 1980 and discussed the evaluation of cardio-respiratory endurance and identified a number of tests to be developed and/or evaluated for that purpose. It was agreed by the Committee for the Development of Sport in 1981 that:

a. The Physical Work Capacity test, at a heart rate of 170 beats per minute (PWC_{170}) using a bicycle ergometer and recording heart rate, was the best available simple field laboratory test for estimating cardio-respiratory endurance in school children, being widely used and comprehensively validated against rigorous criteria.

b. Because bicycle ergometers could not be reasonably expected to be available in all schools, existing simple field tests, using no special apparatus, and suitable for either indoor or outdoor use, according to climate, should be evaluated and, if necessary, new ones devised leading to the final recommendation of a standard test.

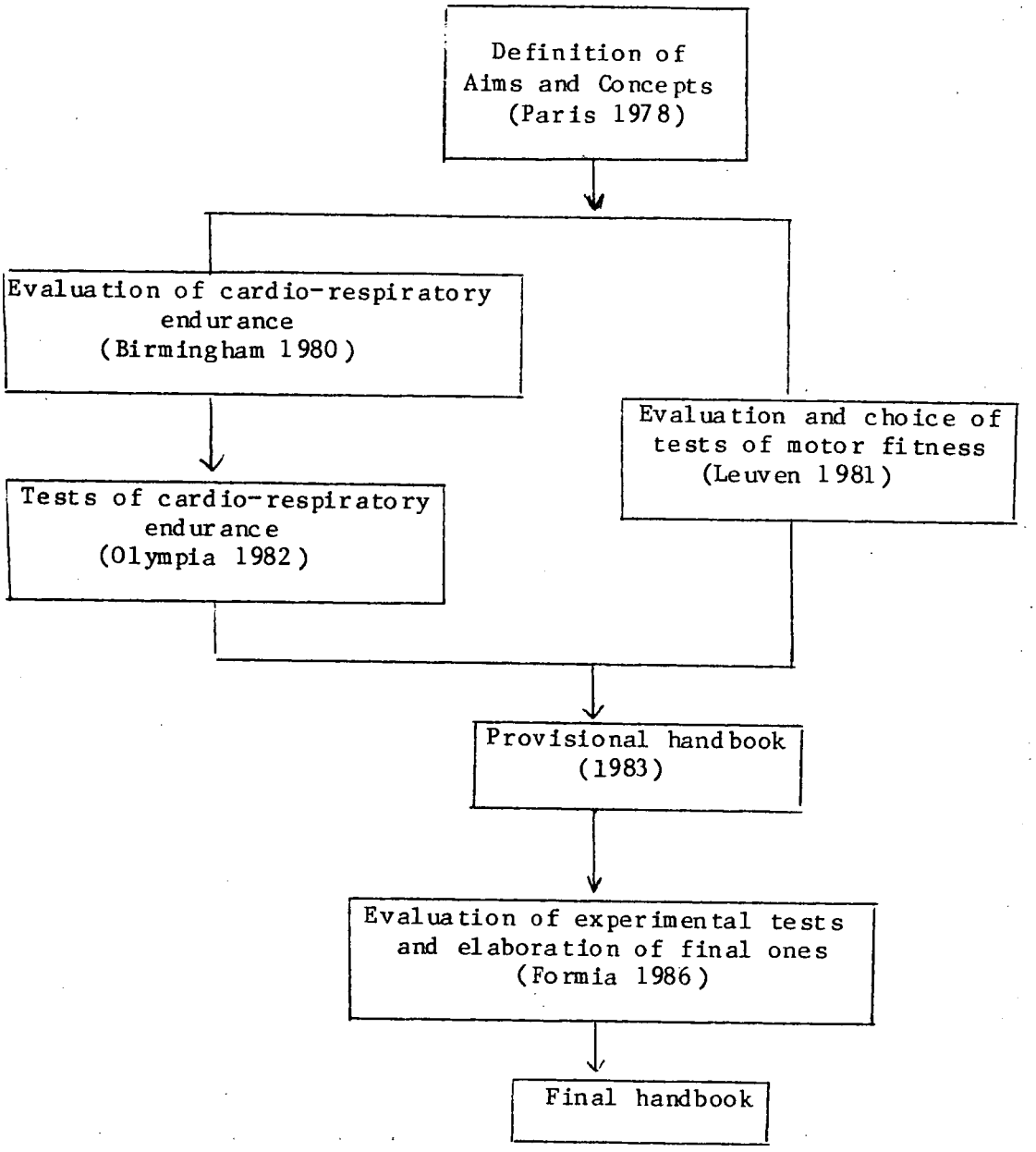
The third seminar was organised by the Institute of Physical Education of the Catholic University of Leuven in Belgium (May 1981). Experts discussed the dimensions of motor fitness and agreed on the contents and the test procedures of an appropriate set of tests. For three factors, a second choice test was added where it met the same selection criteria and had already been adopted in several national studies.

The fourth seminar was held at ancient Olympia organised with the help of the International Olympic Academy and by the Sports Research Institute of the Hellenic Olympic Committee, in order to solve the methodological problems involved in the ergometric procedures of the cardio-respiratory endurance test and to decide on a field test for mass testing situations.

As a result of these four research seminars the Committee of Experts on Sports Research approved a complete experimental EUROFIT test "battery", with ten tests, three alternatives and two possible indoor tests for measuring cardio-respiratory endurance, and the accompanying provisional handbook in 1983. These served as the basis for the invitation to member states to experiment these tests. This was done on a considerable scale (over 50,000 school children in Europe in 15 member states). The results of these experiments were discussed at the fifth and final seminar held at Formia in May1986.

At the Formia Seminar, organised by the Italian National Olympic Committee (CONI), experts evaluated their experiences with the experimental tests and established final testing instruments. The debates focussed on the validity, reliability, objectivity as well as the practicability of the tests. The experimental tests were reviewed, and most were revised and consolidated.

Table I


Definition of Aims and Concepts (Paris 1978)
Evaluation of cardio-respiratory endurance (Birmingham 1980)
Tests of cardio-respiratory endurance (Olympia 1982)
Evaluation and choice of tests of motor fitness (Leuven 1981)
Provisional handbook (1983)
Evaluation of experimental tests and elaboration of final ones (Formia 1986)
Final handbook

3. SELECTION OF AND JUSTIFICATION FOR THE EUROFIT TESTS

Physical fitness is a multidimensional concept so it is not surprising that defining and selecting its parameters have a long and complex history. One of the main objectives of the European research seminars on EUROFIT was indeed to identify its basic dimensions: this was achieved. The details of the discussions and the preparatory research can be found in the published reports of the five EUROFIT seminars (see Appendix III) each contributing to a specific stage in the project, as described in the preceding section.

The criteria agreed for selecting EUROFIT tests were as follows:

- They should be well described, and used with large numbers of children (and sometimes adults) of both sexes.

- Their internal (construct) validity should be established by means of factor analysis in order to ensure independent parameters and to select the most appropriate test for each dimension and factor of physical fitness.

- Their external (concurrent) validity should be demonstrated, that is to say, that they have shown to be effective descriptors of levels of fitness in normal populations and to differentiate between varying groups (eg levels of sports performance or intensity of participation).

- Their reliability and objectivity measures had to be high. This was checked through test-retest procedures on the one hand and through comparing the scores given by different test administrators on the other hand.

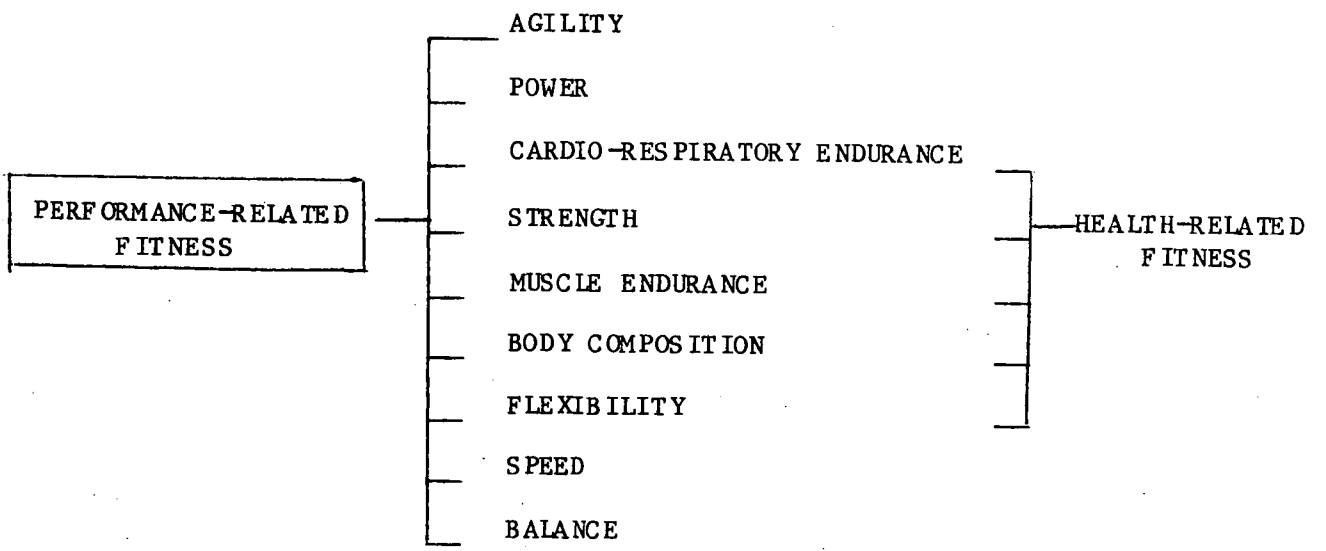
Finally, in addition to their suitability for survey purposes in large scale projects, the tests had to be practical and applicable in school or club situations. Simpler test versions were therefore preferred to more sophisticated ones, provided that this did not undermine the other criteria of validity, reliability and objectivity.

The discussions comparing the scientific criteria with the more practical considerations of applicability and simplicity led to the final selection of 10 tests, measuring six dimensions and nine factors of physical fitness, to which personal measurements and identification data were added (see Table II b).

The table below shows nine components which contribute to physical fitness. As can be seen certain elements are common to both performance-related and health-related fitness. Further, the health-related components have the added value of being essential elements in performance-related fitness.

Table IIa

COMPONENTS OF FITNESS



Although there is still debate about the components (dimensions) which constitute fitness, the division into health and performance related is generally accepted. EUROFIT tests cover all these components.

TABLE II.b : Dimensions and factors of physical fitness and the EUROFIT tests

DIMENSION	FACTOR	EUROFIT TEST	SEQUENCE ORDER FOR TESTING
Cardio-respiratory endurance	Cardio-respiratory endurance	Endurance shuttle run (ESR)	9
		Bicycle ergometer test (PWC 170)	
Strength	Static strength	Hand grip (HGR)	5
	Explosive power	Standing broad jump (SBJ)	4
Muscular endurance	Functional strength	Bent arm hang (BAH)	7
	Trunk strength	Sit-ups (SUP)	6
Speed	Running speed - agility	Shuttle run: 10 x 5 metres (SHR)	8
	Speed of limb movement	Plate tapping (PLT)	2
Flexibility	Flexibility	Sit and reach (SAR)	3
Balance	Total body balance	Flamingo balance (FLB)	1
ANTHROPOMETRIC MEASURES		Height (cm)	
		Weight (kg)	
		Body fat (5 skinfolds: biceps, triceps, subscapular, suprailiac, calf)	
IDENTIFICATION DATA		Age (years, months)	
		Sex	

Rationale

The concept of physical fitness can be divided into three major constituents: organic, motor and cultural. The organic dimension, which is closely linked to the individual's physique, concerns the processes of energy production and work output. This dimension of fitness, the one most directly related to health, is represented in EUROFIT by a choice of cardio-respiratory endurance tests. The first, the endurance shuttle run, is a fairly simple field test in which the subjects perform a monitored multi-stage shuttle run over a distance of 20 metres. It can thus be easily administered in schools either indoors or outdoors. The bicycle ergometer test is a somewhat more complicated test for cardio-respiratory endurance, requiring more sophisticated equipment. Nevertheless, the need for an accurate assessment of the cardio-respiratory endurance of some individuals with problems in this particular aspect of fitness justifies its provision in physical performance laboratories, sport or school health centres, and, most importantly, when undertaking major surveys.

The motor dimension of physical fitness concerns the development of psychomotor capacities required for the control of movement, and of muscular skills in order to carry out some motor tasks. The term "motor fitness" is commonly used to identify this very complex component. It cannot be measured with a single test: it needs a combination of tests, each measuring different factors. Three of its basic components - strength, muscular endurance and speed - themselves comprise more than one factor at least, and two different tests are thus required to evaluate each of these factors. Flexibility and balance are each measured by one test. It is important to stress the fact that the EUROFIT tests have been selected to measure general motor capacities and not movement or sports proficiency. The EUROFIT tests provide relevant information on an individual's basic motor abilities; they are less suited to assessing or predicting the level of technical sport skills. However, all the tests have shown their validity in differentiating, for example, physically active youngsters from non-active ones, or between sport participants from different disciplines. It is impossible to establish a hierarchy between these tests because each measures a different aspect of motor fitness. Whereas strength and speed, for instance, are important qualities in athletics, flexibility and balance are important in gymnastics; whereas boys generally achieve higher scores than girls in strength, muscular endurance and speed, girls may score more highly in flexibility and balance.

The cultural dimension is the third facet of the physical fitness triad. It refers to and reflects the influence of such factors as the situation of physical education in the school system or the accessibility of sport clubs and sport facilities. Furthermore, the value system, the attitudes and behaviour patterns of a given cultural setting determine to a large extent the life style and amount of physical activities of an individual. "Sport for all"

and, let us hope "EUROFIT", are perfect examples which illustrate the impact the cultural component can have on the sports participation and the physical fitness status of large populations. As a consequence, the EUROFIT tests should ideally be complemented with an evaluation of a person's involvement in physical activities. Such an inventory should at least cover a one-year period in order to reflect seasonal variations. At the moment, however, a common European physical activity questionnaire has not been developed (1).

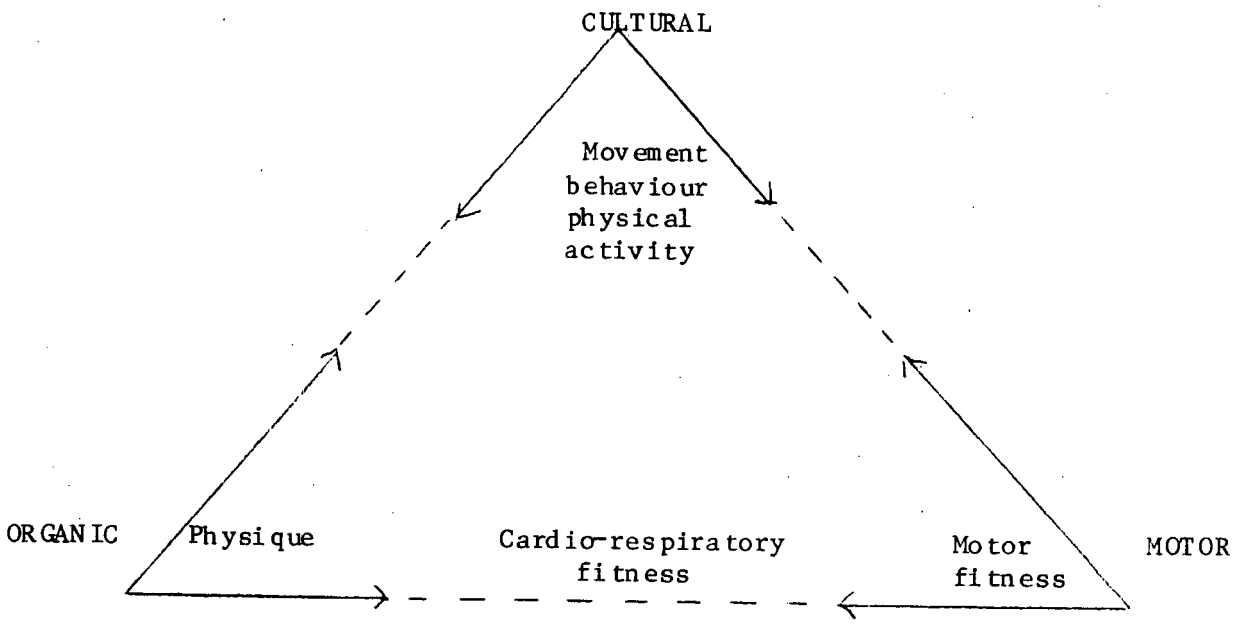


Table III: The physical fitness triad (Renson et al, 1979)

These three components of physical fitness are all interrelated, as had already been shown. Somatic factors may also affect the results in certain tests. Body weight, for instance, effects the result of the static strength test (handgrip) and the functional strength test (bent arm hang). Furthermore an individual's body type - together with his cardio- respiratory and motor fitness - can have a predisposing effect on his sport preference or his performance level. Here we can think of the tall high jumper or basketball player on the one hand and the robust judo or rugby player on the other hand. Because of all this, measurements of height, weight and skinfolds should also be recorded. The skinfold measurements allow the percentage of body fat to be evaluated and this is a more relevant parameter than body weight.

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(1) See Appendix III for a pilot study in Italy on the cultural dimension related to EUROFIT (Reference 10). See also U Claeys, "Rationalising Sports Policies": standardised questionnaire (CDDS (79) 49) and report: CDDS (82) 25).

REFERENCE SCALES

In order to establish national or regional reference scales (norms) and profile charts, the subject's age and sex has to appear on the EUROFIT score-sheet. It goes without saying that a raw score is meaningless in the absence of comparative data. Such reference scales (norms) and profile charts can only be established when a representative group of people have performed the tests under strictly controlled and standardised conditions. Any individual's raw scores can then be referred to the distribution of the scores of the representative sample, in order to find out where his or her position vis-à-vis age and sex. Because of the important variations in physical fitness during growth and between the sexes, separate reference scales and profile charts have to be established for boys and girls of all ages between 6 and 18.

At this moment national or regional reference scales (norms) are only available in some of the countries which have applied some of the EUROFIT tests in large surveys (eg Belgium and the Netherlands) and even then in a fragmentary form. Reference scales for the complete set of EUROFIT tests obviously do not exist yet: each country participating in EUROFIT will be responsible for establishing them in the light of their test results.

PART II: THE EUROFIT TESTS: ADMINISTRATION, SCORING, MEASUREMENTS.

1. GENERAL RECOMMENDATIONS

The EUROFIT tests are an educational tool designed to measure a child's progress in the development of his basic physical attributes. The tests are not exercises and, if they are to fulfil their purpose, they should be neither learned nor practised. EUROFIT is also a scientific research tool for assessing a child's physical fitness.

Organisation of the testing

- The value and effectiveness of the EUROFIT tests will, to a large extent, depend upon strict testing procedures and the motivation given to the children by the PE teacher.

- The tests will usually be administered by the PE teacher in his/her class, but they may also be administered by other people involved in the physical life of the child, such as teachers, the staff of health centres, sports clubs etc.

- The tests should be administered if possible at least once a year to a whole class or half a class. Ideally, each child should be tested twice (at the beginning and end of the school year).

- The tests should be administered in the order in which they are listed in the handbook. However if, for practical reasons, testing takes place in different circumstances (eg on a circuit system), the Flamingo Balance test should always be given at the beginning of the sequence and the endurance shuttle run test at the end; subjects should be given adequate time to recuperate between tests.

- The bicycle ergometer is not likely to be generally available and the PWC_{170} test is therefore optional in the classroom; it is, however, vital for survey work.

- To improve motivation, the administrator should explain fully why the testing is being carried out and comment on the results.

- In order to have comparability, testing conditions should be as identical as possible for each pupil and each sequence (eg location, equipment, temperature, etc).

- The results of the tests should be given to each child individually. This sheet should be in duplicate: for the child to enable him or her to see where he or she stands in comparison to his/her previous performance(s), the average for the class and, possibly, the national average; for the parents to ascertain and encourage the development of their child's physical fitness.

- Reference tables should be drawn up by specialised bodies in each country.

- If the school has computer facilities, a simple programme can be developed enabling each child to enter his own results and make the required calculations.

2. TESTS OF CARDIO-RESPIRATORY ENDURANCE

2.1 Purpose

The human organism has developed three distinct sets of mechanisms for transferring energy from food to a form which can be used by the muscle cell.

In the very first seconds the energy is liberated anaerobically from the energy-rich phosphates stored in the muscle: next, a second and back-up mechanism supplies energy by an anaerobic splitting of the glycogen supply in the muscle cell. During the first four minutes of any muscular performance, a third mechanism starts up which replaces the original anaerobic energy supply with aerobic oxydation of glycogen and fatty acids. To do this oxygen must be transferred from the air to the muscles by ventilation and circulation; this is done by the cardio- respiratory systems.

Using these basic physiological facts, physical performance can be classified according to the duration of the performance.

In all endurance events (ie longer than five minutes) aerobic power is very important. The purpose of the cardio-respiratory endurance test is to assess this aerobic power, ie the ability to perform continuous physical activity where the principal limiting factor is the functional capacity of the entire cardio-espiratory system from lungs to muscles. This is commonly referred to as "general" endurance, and is important in varying degrees to most activities involving running, swimming or cycling, and therefore to all field games, most racket games and many outdoor pursuits. It is also the aspect of fitness most clearly related to physical well-being and in later life will largely determine how far decline in physical activity may be resisted. It is vital therefore to assess the development of this aspect of fitness during childhood, the optimum period for the habit of exercise to be acquired.

2.2 Testing this aspect of fitness

The essential difficulty with testing endurance is to satisfy the criterion of objectivity. It is relatively easy to devise tests whose performance depends principally on aerobic function; it has proved more difficult to devise and apply an objective measure of maximum endurance. In the laboratory it is possible to measure maximum oxygen consumption with a high degree of objectivity if the commonly accepted criteria of maximum performance are carefully observed. The great advantage of the field test is that several children can be tested simultaneously in a short space of time, and that the equipment needed is usually already available in a school.

Recommended as the appropriate test therefore for the measurement of cardio-respiratory endurance in the context of the physical education lesson is the Endurance Shuttle Test which has demonstrated a very high level of validity and reliability (to the extent that it has displaced the 6-minute run test recommended

in the provisional handbook). It must be recognised that this is a test of maximum performance and thus in order to obtain valid measures it is essential that subjects are well-motivated and clearly understand the independence of effort required of them. Those administering this test should therefore keep a close eye on subjects likely to experience difficulties (eg, obese children) so that they produce their maximum effort without over-exerting themselves. Children should not do this test while suffering from colds and other minor infections.

For survey and project use there is a satisfactory compromise between the complicated and expensive laboratory procedure and the simple running test. This test, the sub-maximal Bicycle Ergometer Test (PWC170), uses some of the techniques of the laboratory but much less expensively and is not difficult to administer by anyone who is prepared to understand its operation. Its most valuable feature is its high objectivity, achieved by monitoring physiological responses to measured levels of physical work. It is of particular relevance to health-related fitness and is also of pedagogical value, especially to older children. It does not, however, permit the testing of more than one child at a time. Cycling is well established as an appropriate activity for evaluating aerobic capacity, involving as it does a major percentage of the total body musculature. A further advantage of the test is that at no time does it require maximum exertion from the child. It has been shown to be well received by children, who perform it with positive interest and enjoyment.

This test, which applies the criterion of physical work capacity at a heart rate of 170 beats per minute (PWC170), has been widely used internationally for several years for testing young adults and children of both sexes, and has been satisfactorily validated. It is the preferred test for this aspect of fitness where time and the facilities can be provided.

2.3 Endurance shuttle run test

Factor: Cardio-respiratory endurance

Description of Test: A test of cardio-respiratory fitness, which begins at walking pace and ends running fast, whereby the subjects move from one line to another 20m distant, reversing direction, and in accordance with a pace dictated by a sound signal, which gets progressively faster. (Few subjects will be able to keep going to the end). The stage at which the subject drops out is the indicator of his/her cardio-respiratory endurance.

Equipment needed for the test

- a gymnasium or space large enough to mark out a 20 metre track;
- a 20-metre measure;
- self-adhesive tape to mark the beginning and the end of the 20 metre track;
- a tape recorder, preferably allowing adjustment to the turning speed of the tape;
- a pre-recorded tape of the protocol.

Instructions for the test subject:

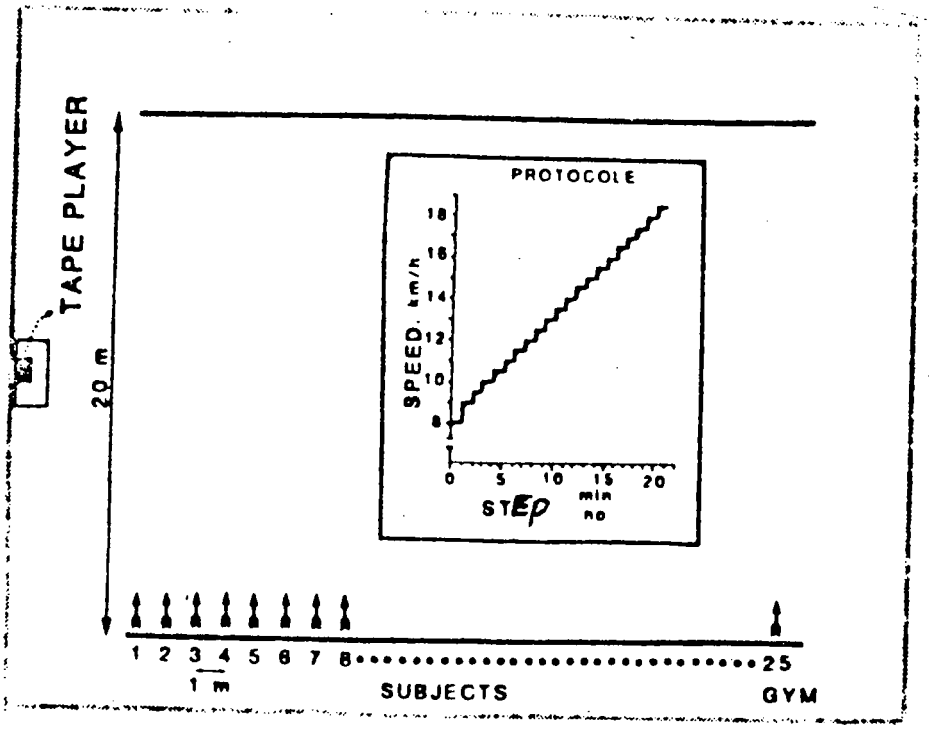
The shuttle run test you are about to take gives an indication of your maximal aerobic capacity, this is, your endurance, and involves running there and back along a 20 metre track.

Speed will be controlled by means of a tape emitting buzzing sounds at regular intervals. Pace yourselves so as to be at one end of the 20 metre track or the other when you hear a sound. Accuracy to within one or two metres is enough. Touch the line at the end of the track with your foot, turn sharply and run in the opposite direction.

At first the speed is low but it will increase slowly and steadily every minute. Your aim in the test is to follow the set rhythm for as long as you can. You should therefore stop when you can no longer keep up with the set rhythm or feel unable to complete the one minute period. Note the number announced by the recording when you stop - that is your result or score. The length of the test varies according to the individual: the fitter you are, the longer the test lasts.

To sum up, the test is maximal and progressive, in other words easy at the beginning and hard towards the end. Good Luck!

FIGURE 1



Instructions for the person administering the test:

- Study the graphic representation of the test protocol (see figure 1).

- Select test site; allow for a space of at least one metre at either end of the track. The wider the area used, the more the number of subjects that can be tested simultaneously: the space for each subject should be a minimum of one metre. The surface should be uniform but the material of which it is made is not specifically important. The two ends of the 20 metre track should be clearly marked.

- Check the functioning of the sound track and tape recorder. Ensure that the apparatus is powerful enough for group testing.

- Listen to the contents of the sound track. Note the numbers on the tape position indicator so as to be able to locate the key sections of the tape quickly.

- Check the tape speed of the recorder or cassette player to be used on the day of the test. For this, use the one minute calibration period recorded at the beginning and end of the tape. If this differs by more than one second, adjust the running distance so that the right speed is run. This can be done using the correction factors at Table V.

Score: After the subject has stopped, the last completed step is noted (see table IV).

TABLE IV

Endurance shuttle run test

Step (Minutes)	Speed (km/h)	Split time (Seconds)
1	8	9,000
2	9	8,000
3	9.5	7,579
4	10	7,200
5	10.5	6,858
6	11	6,545
7	11.5	6,261
8	12	6,000
9	12.5	5,760
10	13	5,538
11	13.5	5,333
12	14	5,143
13	14.5	4,966
14	15	4,800
15	15.5	4,645
16	16	4,500
17	16.5	4,364
18	17	4,235
19	17.5	4,114
20	18	4,000
21/23	18.5	3,892

SOUND TRACK CONTENTS for the
Multistage 20 metre shuttle run with steps of 1 minute

A. Location of the test protocol on the tape

"To facilitate location of the various parts of the tape, you hear the count-down: 'three, two, one, zero'. At zero, set the tape position indicator to 'zero'. Stand by: 'three, two, one, zero'."

B. Identification of test

Endurance shuttle test.

C. Checking tape recorder speed

"Standard period of one minute to check tape recorder speed. Start stop-watch at 'go'. Stand by. 'Three, two, one go' (set stop-watch in motion) ... Stand by for stopping stop-watch: 'stop' (stop stop-watch). End of standard period of one minute.

D. Starting instructions

The test will start in 30 seconds. Line up at the start. Run for as long as possible, keeping in your lane. Always run in a straight line. If you stop, you stop - no rests are allowed. When you do stop, note the last number announced for the relevant period - this is your result, so don't forget! The test will start in five seconds' time when the buzzer sounds: 5, 4, 3, 2, 1 'Buzz'.

... buzz ... buzz ...
Beginning of step 1 ... buzz ... buzz ...
Step 2 ...
(and so on to step 21)
End of recording."

Note on the procedure for recording a sound track for the multistage 20 metre shuttle run
(see also Table V)

The use of an electronic recording method is preferable but requires more sophisticated equipment. The manual method is acceptable: even though the chances of error with each sound signal are greater, the margin of error fluctuates and evens out from one signal to the next, the overall effect being practically nil after a two minute period. What matters is systematic error (clock gaining or losing) which should be lower than 1% (ie 0.01 sec).

- The information to be recorded will include sections A, B, C, D from the preceding page, plus the full test protocol outlined at the end of Section D.

- Equipment needed:

1. Cassette or reel-to-reel tape recorder (mono or stereo). A "pause" facility is useful.

2. Microphone.

3. Clock with sweep seconds hand (duration of periods).

4. Manually-operated clock with non-cumulative split timing facility (timing of intervals between sound signals).
or Electronic clock with adjustable cycles (length of intervals between sound signals). Accuracy to within 1% (gain or loss) is acceptable, ie to within 0.01 sec.

5. Sound source (electric bleeper; whistle, voice). With the electronic method, it must be possible to connect the sound source to the electronic clock. A frequency generator may be used to change the sound frequency from one period to the next.

6. Magnetic tape for a 20 minute recording. 900 foot tape running at 9.5 cm/s (3 ¾ ips) or 45 minutes cassette.

Table V

Shuttle distance adjustment according to cassette player speed. A 60 seconds standard time period is provided. With a stopwatch (accurate to 1/10 sec) check if the duration of the standard time period is actually 60 seconds long. If it is shorter or longer than 60 seconds correct the 20m running distance using the table.

Standard Time Period (seconds)	Distance To Run (metres)
55.0	18.333
55.5	18.500
56.0	18.666
56.5	18.833
57.0	19.000
57.5	19.166
58.0	19.333
58.5	19.500
59.0	19.666
59.5	19.833
60.0	20.000
60.5	20.166
61.0	20.333
61.5	20.500
62.0	20.686
62.5	20.833
63.0	21.000
63.5	21.166
64.0	21.333
64.5	21.500
65.0	21.666

CAUTION: With more than a five second error on the standard time period, change the tape player for another one!

2.4 Bicycle ergometer test (PWC170) (for survey and project work)

Factor: cardio-respiratory endurance (sub-maximal aerobic power)

1. Description of test

This test is performed on a stationary cycle ergometer, the subject being required to pedal continuously, for a total of not more than nine minutes, during which time the workload is increased twice (at three and six minutes), making three loads in all. Heart rate is measured during the last 15 seconds of each load, and the workload increases are regulated so that the heart rate achieved at the end of the test approaches 170 beats per minute. It is then possible to determine the workload corresponding to a heart rate of 170 beats per minute by extrapolation (or interpolation). The higher this value, the fitter the individual. As the subject's body weight is supported while cycling, and yet cardio-respiratory endurance most usually entails carrying one's body weight, the score is made more meaningful if divided by the subject's weight in kilograms.

2. Conditions for the bicycle ergometer test

a. Preparation and motivation

The children, with due consideration of intelligence and age, should be as carefully prepared as possible for the test and encouraged to feel that it is enjoyable but serious and important. This preparation should not involve practice of the test itself.

b. Administrative continuity and consistency of procedure

In the absence of the ideal conditions whereby the same tester is responsible for all testing, absolute consistency of test procedures must be ensured. Even apparently trivial modifications may affect the performance of the test and thus the validity and comparability of the scores achieved. For example:

i. A heavy meal should not closely precede the test, a minimum of one hour being allowed. Conversely if the children are to be tested during the morning it is important to ensure that they have had some breakfast including some carbohydrate.

ii. Too cold or too hot a room will adversely affect heart rate response to exercise. The temperature should be of the order of 18 to 22 °C. The upper limit especially should not be exceeded if possible for endurance tests.

iii. Strenuous endurance-type exercise should obviously be avoided on the day (before the test is performed).

iv. The isolation of the test room as much as possible from external disturbances (noise, intrusion, spectators, etc).

v. Children suffering from colds should be tested at another time.

c. Physiological and psychological considerations

Children should arrive in the room in an unexcited state at least 10 minutes before their test is to begin, change into sports/PE clothes and shoes and sit quietly awaiting their turn. Most children find it helpful and reassuring to see the previous subject performing, but sensitive or physically self-conscious children (such as the very obese) should be given privacy.

3. Equipment needed for the test

a. Bicycle ergometer, which should be:

i. mechanically braked by a friction belt, tensioned by suspended weights or pendulum system. Accurate calibration and adjustability of resistance is essential;

ii. fitted with a pedal revolution meter, and

iii. suitable for the size of child being tested (for example most adult stationary bicycles are not suitable for children less than about 1m 35 in height). Adequate adjustment of saddle and handle bars should be provided. For small children pedals with a simple toe strap are preferable.

b. Stopwatch)
) or other equipment for heart rate measurement.
c. Stethoscope)

d. Clock

e. Weighing scales (kilograms)

4. Method

a. HEART RATE MEASUREMENT

i. The recommended method for this measurement, based on cheapness and accuracy, is for the time for 15 heart beats to be recorded using stethoscope and stopwatch, but it can only be performed reliably after substantial practice, preferably on a variety of physiques. See the box on the following page.

ii. Alternatively, the heart rate may also be recorded by timing 15 beats by direct observation on an electrocardiograph; or by use of a cardiac rate meter if it is of proven accuracy and reliability.

Heart rate measurement by the stethoscope and stopwatch method

a. With the subject seated on the bicycle before the test begins, the administrator locates the best position for listening to the subject's heartbeat (usually immediately below the lower border of the pectoralis major muscle or left breast and 2 or or 3 cms medial of the nipple, see 3). Warm the stethoscope before applying it to the subject's skin.

b. The heart rate is measured during the test while the subject is cycling, care being taken to locate the stethoscope a few seconds before counting is to begin.

c. To obtain the time for 15 heartbeats, 15 intervals must be timed, ie 16 beats are involved. The best way is to count the first beat as ZERO, simultaneously starting the watch, and counting subsequent beats as ONE, TWO, THREE and soon, the watch being stopped on the count of FIFTEEN.

d. The rate per minute is then calculated by the formula:

900 divided by the time in seconds for 15 beats,

or from the table below:

Heart rate in beats per minute from time for 15 beats

Time (15 secs)	Rate (beats min -1)	Time	Rate
15.0	60	6.4	141
14.5	62	6.2	145
14.0	64	6.0	150
13.5	67	5.9	153
13.0	69	5.8	155
12.5	72	5.7	158
12.0	75	5.6	161
11.5	78	5.5	164
11.0	82	5.4	167
10.5	86	5.3	170
10.0	90	5.2	178
9.5	95	5.1	176
9.0	100	5.0	180
8.5	106	4.9	184
8.0	113	4.8	188
7.5	120	4.7	191
7.0	128	4.6	196
6.8	132	4.5	200
6.6	136	4.4	205

It will be evident from the table that accurate use of the stopwatch is essential.

b. WORK LOAD INCREASES

i. This is performed after the heart rate measurement and at the end of each load period by either:

a. addition of weights to the cradle on the ergometer, or

b. adjustment of the friction control with the pendulum weight system.

NB: In (b) it is very important to comply strictly with the manufacturer's calibration instructions; to check that the zero position of the pendulum weight with the subject on the the bicycle; and to make any necessary adjustment to the resistance setting during the initial period of each load as the friction belt and wheel rim heat up.

ii. The pendulum weight scale being non-linear, only settings at the intervals marked on the scale can be used. It is easier to have a scale with direct readings in watts marked for a standard pedal speed of 60 rpm.

c. SETTING THE LOAD

The initial load has to be set at a somewhat arbitrary value, the traditional procedure being to set one watt per kilogram body weight of the subject. This sometimes results in the first load being excessive (particularly for obese children) and a lower initial setting is preferable for girls. Further increases are set according to heart rate response, allowing a regulated progression of work carefully adjusted to the exercise capacity of the individual child. It is suggested that an initial load of 3/4 W kg -1 is appropriate for girls, going down to 1/2 W kg -1 for relatively obese and/or non-sports participating girls. Non-obese girls of known sporting prowess might then be given 1 W kg -1 as a starting load, or higher in exceptional cases.

For boys, the equivalent initial loads should be 1 W kg -1, 3/4 W kg -1 and 1 1/4 W kg -1 respectively.

	OBESE OR UNFIT	NORMAL	FIT
BOYS	¾	1	1 1/4
GIRLS	½	¾	1

UNITS: W KG-1

When skinfold measures of body fat are used (see pages 44-45), lean body mass can be calculated, leading to a starting load of 1 watt per kilogram of lean body mass.

5. Calculation of increases

Ideally the initial loading and subsequent increases should produce an even progression from a heart rate of around 90-120 beats min -1 at the end of the first load period to just below 170 beats min -1 at the end of the last load period. The tables on the following page will be appropriate in most cases.

Pace control is vital to the accuracy of the workload. A clear pointer, such as a large red arrow, should be stuck to the dial at the 60 rpm position.

Table VI for calculating increases for the 2nd load from heart rate in the 1st load period

If heart rate at the end of the first load period is less than 100,	increase load by 70%
" " " " " " " " " " " "	100 to 110
" " " " " " " " " " " "	increase load by 60%
	111 to 120
" " " " " " " " " " " "	increase load by 50%
	121 to 130
" " " " " " " " " " " "	increase load by 40%
	131 to 140
" " " " " " " " " " " "	increase load by 30%
	141 to 150
" " " " " " " " " " " "	increase load by 20%
	151 to 155
	increase load by 10%

NB: If the heart rate exceeds 155 for the first load period the test should be abandoned and repeated on another day with a lower starting load. The possibility that the child might have been upset or is unwell should be checked before retesting.

Table VII for calculating increases for the 3rd load from heart rate in 2nd load period.

If heart rate at the end of the 2nd load period is less than 130	increase load by 70%
" " " " " " " " " " " "	130 to 140
" " " " " " " " " " " "	increase load by 50%
	141 to 151
" " " " " " " " " " " "	increase load by 30%
	151 to 165
	increase load by 10%

NB: If the heart rate exceeds 165 beats min -1 for the 2nd load period the test should cease. Ideally, the proper course of action is to retest on another day with lower initial + 2nd loads. However if this is impracticable, final heart rates and loads for load periods one and two may be used for the calculation of PWC170.

Table VIII: for choosing the appropriate percentage load adjustments (2nd and 3rd loads)

NB: These adjustments are based on the minimum increments available for suspended weights ergometers, ie 6 Watts at 60 pedal revolutions per minute (one/0.1 kg weight). In the case of other ergometers the nearest load to the one given should be used.

Loads (Watts)	+10%	+20%	+30%	+40%	+50%	+60%	+70%
30	36 (0.1)	36 (0.1)	42 (0.2)	42 (0.2)	48 (0.3)	48 (0.3)	54 (0.4)
36	42 (0.1)	42 (0.1)	48 (0.2)	48 (0.2)	54 (0.3)	60 (0.4)	60 (0.4)
42	48 (0.1)	48 (0.1)	54 (0.2)	60 (0.3)	66 (0.4)	66 (0.4)	72 (0.5)
48	54 (0.1)	60 (0.2)	60 (0.2)	66 (0.3)	72 (0.4)	78 (0.5)	84 (0.6)
54	60 (0.1)	66 (0.2)	66 (0.2)	78 (0.4)	84 (0.5)	84 (0.5)	90 (0.6)
60	66 (0.1)	72 (0.2)	78 (0.3)	84 (0.4)	90 (0.5)	96 (0.6)	102 (0.7)
66	72 (0.1)	78 (0.1)	84 (0.3)	90 (0.4)	102 (0.6)	108 (0.7)	114 (0.8)
72	78 (0.1)	84 (0.2)	96 (0.4)	102 (0.5)	108 (0.6)	114 (0.7)	120 (0.8)
78	84 (0.1)	96 (0.2)	102 (0.4)	108 (0.5)	114 (0.6)	126 (0.8)	132 (0.9)
84	90 (0.1)	102 (0.3)	108 (0.4)	120 (0.6)	126 (0.7)	132 (0.8)	144 (1.0)
90	96 (0.1)	108 (0.3)	114 (0.4)	126 (0.6)	132 (0.7)	144 (0.9)	150 (1.0)
96	102 (0.1)	114 (0.3)	126 (0.5)	132 (0.6)	144 (0.8)	156 (1.0)	162 (1.1)
102	114 (0.2)	126 (0.4)	132 (0.5)	144 (0.7)	150 (0.8)	162 (1.0)	174 (1.2)
108	120 (0.2)	132 (0.4)	138 (0.5)	150 (0.7)	162 (0.9)	174 (1.1)	186 (1.3)
114	126 (0.2)	138 (0.4)	150 (0.6)	162 (0.8)	174 (1.0)	180 (1.1)	192 (1.3)
120	132 (0.2)	144 (0.4)	156 (0.6)	168 (0.8)	180 (1.0)	192 (1.2)	204 (1.4)
126	138 (0.2)	150 (0.4)	162 (0.6)	174 (0.8)	186 (1.0)	204 (1.3)	216 (1.5)
132	144 (0.2)	156 (0.4)	174 (0.7)	180 (0.8)	198 (1.1)	210 (1.3)	222 (1.5)

- The figures not in brackets are the total increased load.

- The figures in brackets are the amount of weight in kilos that needs to be added: eg a load of 72 Watts needing to be increased by 50% is adjusted to that level, ie 108 Watts, by the addition of 0.6 kg to the existing weights in the cradle.

6. Procedure (see also 2 (b))

a. The child removes shoes and is weighed to the nearest 0.1 kg.

b. Having replaced shoes while waiting for the test to begin, the child then sits on the bicycle.

c. Saddle height and handlebar position are adjusted so that:

i. the knee is slightly bent with the pedal in the bottom position (ball of foot on pedal)

ii. the handlebar height permits a slight lean forward of the trunk with the arms straight.

d. The best stethoscope placement is found (see page 27) or other method of heart rate recording applied and checked for function.

e. The child has a brief practice at pedalling at the required cadence. The administrator checks that he can hear the heart beat during this practice if the stethoscope method is to be used.

f. Instructions for the test subject.

When I tell you to start, I want you to begin pedalling gently, gradually building up to the speed shown by the arrow. I am going to put some load on the bike so that you have some work to do. You'll see me adjust the load twice during the test and the work will become a little harder - but don't worry, it won't be too hard at any time - most people find it quite enjoyable. (I'll also need to listen to your chest from time to time during the test, but don't let it bother you). Try to concentrate on pedalling at the right rhythm. You'll be cycling for nine minutes altogether. Right start now.

g. The clock is started when the load has been set and the child has managed to achieve the right cadence - usually within 10-15 seconds.

h. The test then progresses with heart rate being counted or timed during the last 15 seconds of each load period. With practice this can be done, rate calculated and the next load selected and set within 20 seconds, ie not more than five seconds into the next load period. It is helpful if the stethoscope is located several seconds before counting is to commence. A ratemeter obviously makes the procedure easier.

NB: The importance of practising this procedure cannot be over-emphasised. A flustered, uncertain administrator will upset the child and almost certainly raise the heart rates, thus invalidating the test.

In summary the test procedure whether using stethoscope and stopwatch or ratemeter is as follows:

0.00 (regular cadence achieved) . clock started, child pedalling at 1st load;

		Stethoscope	Rate meter
	(2.35 approx.	stethoscope located	
Load	(2.45 approx.	counting commences	heart rate recorded
one	(3.00	second load set	second load set
	(5.35 approx.	stethoscope located	
Load	(5.45 approx.	counting commences	heart rate recorded
two	(6.00	third load set	third load set
	(8.35 approx.	stethoscope located	
Load	(8.45 approx.	counting commences	heart rate recorded
three	(9.00	end of test	end of test

---

i. At the end of the test it is desirable to reduce the load to the order of the initial load and allow the subject to pedal for a further 30 seconds or so to "limber down" before stopping.

j. All data should be noted down as recorded, using a format or sheet similar to that suggested below at paragraph 8.

7. Calculating the fitness score - PWC170

The fitness score is calculated from the heart rates in loads 2 and 3. Either a graph can be drawn plotting heart rate against load so that the load which could be achieved at a heart rate of 170 beats per minute can readily be assessed by extrapolating or interpolating or the following formula may be used:

$$= \frac{(W3 - W2)}{(HR\ 3 - HR2)} \times (170 - HR3) + W3$$

$$PWC170 = \frac{\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad}{BWt} W\ Kg^{-1}$$

where HR2 + 3 are heart rates at loads 2 and 3 respectively,

W2 + 3 are workloads in watts at loads 2 and 3 respectively,

and BWt is body weight in kilograms.

Example: A child of 50 kg has a final heart rate at load 2 of 140 beats per minute, and at load 3 of 162 beats per minute, and for this child load 2 = 66 watts and load 3 = 102 watts,

$$PWC170 = \frac{\frac{(102 - 66)}{(162 - 140)} \times (170 - 162) + 102}{50}$$

$$= 2.3 \text{ watts per kg}$$

---

8. Suggested PWC170 recording sheet

Subject No. .....

Name ..... Date of birth .....

Sex ..... Date of test .....

		CODE
Height ..... cm		
Weight ..... kg	|__|__|__|	BWt
0 min:00 sec Initial load (Watts)	|__|__|__|	W1
2 min:45		
Time for 15 heartbeats	|__|__|__|	TB1
to 3 min:00 (tenths of sec)		
Therefore heart rate (beats min -1) =	|__|__|__|	HR1
3 min:00 sec Second load (Watts)	|__|__|__|	W2
5 min:45		
to 6 min:00 Time for 15 heartbeats	|__|__|__|	TB2
therefore heart rate =	|__|__|__|	HR2
6 min:00 sec Third load (Watts)	|__|__|__|	W3
8 min:45		
to 9 min:00 Time for 15 heartbeats	|__|__|__|	TB3
therefore heart rate =	|__|__|__|	HR3

Observations on test and/or condition of child.

Tester:

3. THE MOTOR FITNESS TESTS

GENERAL TESTING DIRECTIVES

- The subjects perform all the tests with bare feet and in PE/sports clothes.
- All the tests should, if possible, take place in a well-ventilated large room, eg a school gymnasium or sports hall. A non-slip surface is necessary for the running and jumping tests. Testing conditions when outdoors vary too much to obtain standardised test results.
- The sequence of motor tests is organised in a circuit system with a strict testing order. Each station should therefore be marked with its appropriate number. If the tests are divided into two circuits, the test order must still be followed (see p. 16 and below).
- Each test has specific instructions which need careful study and must be read to each subject in order to make the testing as objective as possible.
- No warm-up or stretching exercises are allowed before the tests start.
- The subjects should remain at rest between each test.
- The subjects are not allowed to have a preliminary trial of the test unless this is explicitly stated in the test instructions.
- It is important to encourage the subject during the testing. The test leader should encourage a precise, rapid or consistent performance, according to the factor being measured.
- If these motor tests are done on the same day as one of the cardio-respiratory endurance tests, the motor test should be done first.

Sequence for the motor fitness tests

1. Flamingo balance test (FLB) (should always be done first)
2. Plate tapping (PLT)
3. Sit and reach (SAR)
4. Standing broad jump (SBJ)
5. Hand grip (DYN)
6. Sit-ups (SUP)
7. Bent arm hang (BAH)
8. Shuttle run: 10 x 5m (SHR) (should always be done last)

1st TEST: FLAMINGO BALANCE TEST (FLB)

Factor: General balance

Description of test: Balancing on one leg as a beam of set dimensions.

Material

- A metal beam 50 cm long, 4 cm high and 3 cm wide, covered with a material (max. thickness: 5 mm) securely fastened to the beam. Two suppports 15 cm long and 2 cm wide provide stability. The more beams there are, the more people can be tested simultaneously.

- One stopwatch per beam (without automatic "reset" (zero-setting) so that it counts after stopping and a subsequent restart).

Instructions for the subject

"Try and stay balanced as long as possible on the long axis of the beam while standing on your preferred foot. You bend your free leg backwards and grip the back of the foot with your hand on the same side, standing like a flamingo. You may use your other arm to keep your balance. I will help you to place yourself in the correct position by supporting you with my forearm. The test begins as soon as you release my supporting arm. Try to keep balanced in this position for one minute. Each time you lose your balance (ie when you let go your free leg, the one you are holding) or when you touch the floor with any part of your body, the test stops. After each such fall, the same procedure starts all over again until one full minute has elapsed".

Directives for the test leader

- Place yourself in front of the subject.

- The subject is allowed one trial to become familiar with the test and to make sure that the instructions are understood.

- The test is carried out after this trial.

- Start the stopwatch when the subject releases your supporting arm.

- Stop the watch as soon as the subject loses balance by releasing his free leg or when he touches the floor with any part of his body.

- After each fall help the subject back to the correct start position.

Score

- The number of attempts (not falls) needed to keep in balance on the beam for one whole minute.

Example: a subject with 5 attempts to keep in balance for one minute scores 5.

Attention: Should the subject fall 15 times within the first 30 seconds, the test is ended and the subject gets a zero score (ie the subject is unable to perform the test). This may happen with children of 6 to 9 years.

2nd TEST: PLATE TAPPING (PLT)

Factor: Speed of limb movement

Description of test: Rapid tapping of 2 plates alternately with the preferred hand.

Material

- Table, adjustable in height (or in a gym, a vaulting box)
- Two rubber discs, each 20 cm in diameter, are fixed horizontally on a table. The centre points of the disc are 80 cm apart (edges therefore 60 cm apart). A rectangular plate (10 x 20 cm) is placed between the two discs equidistant from each disc.
- Stopwatch.

Instructions for the subject

"Stand in front of the table feet slightly apart. Place your non-preferred hand on the rectangular plate in the centre. Place your preferred hand on the opposite disc. Move your preferred hand back and forth between the two discs as quickly as possible, over the hand in the middle. Be sure to touch the disc each time. When I say 'ready ... start!', perform 25 cycles as quickly as possible. Stop when I give the signal 'stop', I will count your score aloud. You do the test twice and the better time is the score."

Directives for the test leader

- Adjust the table so the top is just below the umbilical level.
- Sit in front of the table; concentrate on the disc chosen by the subject at the beginning of the test and count the number of taps on this disc.
- Start the stopwatch at the signal "ready ... start!". Assuming the subject starts on disc A, the stopwatch is stopped when he/she touches this disc for the 25th time. Thus the total number of taps on the disc A and disc B amounts to 50 taps, or 25 cycles between A and B.
- The hand on the rectangular plate stays there during the whole test.
- The subject is allowed to have a trial before the test in order to choose the preferred hand.
- A rest period is given between the two attempts. During this time another subject can perform his first trial.
- 2 test leaders are strongly recommended for this test: one to time and to encourage; the other to count the taps.

Score

- The better result is the score. The score is the time needed to touch each disc a total of 25 times, recorded in tenths of a second.
- If the subject fails to touch a disc, an extra tap is added in order to reach the required 25 cycles.

Example: a time of 10.3 sec scores 103.

3rd TEST: SIT AND REACH (SAR)

Factor: Flexibility

Description of test: Reaching forward as far as possible from a seated position.

Material

- A test table or box with the following dimensions: length 35 cm; width 45 cm; height 32 cm. The measurements of the top plate are: length 55 cm; width 45 cm. This top plate extends 15 cm over the side supporting the feet. A scale from 0 to 50 cm is marked in the middle of the top plate.

- A ruler of c. 30 cm loose on the top of the box which the subject moves as he moves his hands on the top of the box.

Instructions for the subject

"Sit down. Place your feet flat against the box, your fingertips on the edge of the top plate. Bend your trunk and reach forward as far as possible keeping your knees straight and slowly and gradually push the ruler in front of you, without jerking and with your hands stretched out. Remain still in the farthest position you can reach. Don't bounce. The test will be done twice with the better result counting as the score."

Directives for the test leader

- Stand beside the subject and keep his/her knees straight.

- The subject should reach the edge of the top-plate, touching the ruler, before beginning to reach.

- The score is determined by the farthest position the subject reaches on the scale with his/her fingertips. The subject must hold this position at least for a count of two so that the score can be read correctly.

- If the fingers of both hands do not reach the same distance, take the average distance of the two fingertips.

- The test must be done slowly and progressively without any bouncing movements.

- The second trial follows after a short rest period.

Score

- The better result is the score, in centimetres (cm reached on the scale on the top of the box).

Example: a subject who reaches his toes scores 15. One who reaches 7 cm past his toes scores 22.

4th TEST: STANDING BROAD JUMP (SBJ)

Factor: Explosive strength

Description of test: Jumping for distance from a standing start

Material

- Non-slip hard surface, preferably two judo or similar (eg gym) mats (set lengthwise next to each other).
- Chalk.
- A tape measure.

Instructions for the subject

"Stand with your feet the normal distance apart and toes just behind the line. Bend your knees with your arms in front of you, parallel to the ground. As you swing both arms push off vigorously and jump as far as possible. Try to land with your feet together and to stay upright. The test is done twice and the better one counts."

Directives for the test leader

- Horizontal lines are drawn on the landing-mat 10 cm apart, parallel to and starting 1 m from the take-off line.
- A tape measure taped perpendicularly to these lines gives accurate measurements.
- Stand on one side and record the distances jumped.
- The distance is measured from the front edge of the take-off line to the point where the back of the heel nearest to the take-off line lands on the mat.
- A further attempt is allowed if the subject falls backwards or touches the mat with another part of the body.
- The take-off and landing mats must be on the same level and firmly fixed to the floor.
- As scoring differences can be significant, be accurate when measuring.

Score

- The better of the two attempts is the score. The result is given in cm.

Example: a jump of 1 m 56 cm scores 156.

5th TEST: HANDGRIP (DYN)

Factor: Static strength

Material

- A calibrated hand dynamometer with adjustable grip.

Instructions for the subject

"Take the dynamometer in your preferred hand. Squeeze it as forcefully as you can while holding the dynamometer away from your body. Don't let it touch you during the test. Squeeze gradually and continuously for at least 2 seconds. Do the test twice: the better result scores."

Directives for the test leader

- Recalibrate the dynamometer to zero before each test subject and see that the dial of the dynamometer faces the tester during the test.
- Ask the subject to use his preferred hand. Adjust the grip so that the two bars correspond to the first phalange of the middle finger.
- During the test, the arm and hand holding the dynamometer should not touch the body. The instrument is held in line with the forearm and hangs down at the side.
- After a short rest a second attempt is made.
- The indicator needle need not be returned to zero after the first attempt; the tester only needs to check if the second attempt is better than the first.

Score

- The better result is the score recorded in kilograms (accurate to 1 kg).

Example: a result of 24 kg scores 24.

6th TEST: SIT-UPS (SUP)

Factor: Trunk strength (abdominal muscular endurance)

Description of test: Maximum number of sit-ups achievable in 1/2 minute.

Material

- 2 mats (set lengthwise next to each other).
- Stopwatch.
- Assistant.

Instructions for the subject

"Sit down on the floor, back upright, hands clasped behind your neck, knees bent at 90 degrees heels and feet flat on the mat. Then lie down on your back, shoulders touching the mat, and return to the sitting position with your elbows out in front so that they touch your knees. Keep your hands clasped behind your neck the whole time. When I say 'Ready ... start' repeat this action as rapidly as possible for 30 sec. Continue until I say 'Stop!'. You do this test once."

Directives for the test leader

- Kneel at the side of the subject, checking the correct starting position.
- Sit facing the subject with legs apart, thighs over the subject's feet to keep them on the ground. Put your hands in the bends of the subject's knees, thus maintaining a right angle (90°) and the legs still.
- After giving the instructions and before the test begins, the subject executes the entire movement once, to make sure that he has understood.
- Start the stopwatch at the signal "Ready ... start!" and stop after 30 sec.
- Count aloud each time a complete, correct sit-up is performed. One complete sit-up goes from the sitting position, to the mat and back to the sitting position, elbows touching the knees.
- Count when the elbows touch the knees. No count means that the sit-up was not performed correctly.
- During the performance correct the subject if he doesn't touch the mat with his shoulders or his knees with his elbows when returning to the starting position.

Score

- The total number of correctly performed complete sit-ups in 30 seconds is the score.

Example: 15 correct performances scores 15.

7th TEST: BENT ARM HANG (BAH)

Factor: Functional strength (arm and shoulder muscular endurance)

Description of test : Maintaining a bent arm position while hanging from a bar

Material

- A round horizontal bar, diameter 2.5 cm, set so that the subject when standing below it, can reach it without jumping (sometimes more for taller subjects).
- Stopwatch.
- A mat below the bar to land on.
- Cloth and magnesium chalk.
- Optional: bench or chair.

Instructions for the subject

"Stand under the bar fingers on top, thumb underneath, and place your hands, shoulder-wide, on the bar with a forward grip. I will help lift you up until your chin is above the bar. Hold this position as long as possible without resting your chin on the bar. The test ends when your eyes go below the bar."

Directives for the test leader

- The subject stands under the bar with hands in a forward grip on the bar at shoulder width. Be careful: most subjects try to place their hands too far apart.
- The height of the bar is adjusted to the height of the tallest subject. Don't frighten them by making it too high.
- Watch in one hand, take the subject by the thighs and lift him with the other into the correct position.
- The watch is started the moment the subject's chin goes above the bar and is let go.
- Swinging movements by the subject should be stopped; give encouragement.
- Stop the watch when the subject cannot hold the required position any longer as described above (eyes below the bar).
- Don't tell the time to the subject during the test.
- Clean the bar between subjects with a cloth. The subjects can chalk their hands.
- A chair or bench may help subjects reach the bar.

Score

- The time in tenths of a second is the score.

Example: - a time of 17.4 sec, scores 174
- a time of 1 min 03.5 sec, scores 635.

8th TEST: SHUTTLE RUN, 10 x 5 metres (SHR)

Factor: Running speed, agility

Description of test: A running and turning (shuttle) test at maximum speed.

Material

- Clean, slip-proof floor. If a mat is used, make sure it is secured properly.
- Stopwatch.
- Measuring tape.
- Chalk or tape.
- Traffic cones (skittles).

Instructions for the subject

"Get ready behind the line. One foot should be just behind the line. When the start is given, run as fast as possible to the other line and return to the starting line, crossing both lines with both feet. This is one cycle, and you have to do it five times. On the fifth time, do not slow down when coming to the finish but continue running. The test is done once".

Directives for the test leader

- Two parallel lines are drawn on the floor (with chalk or tape) 5 m apart.
- The line is 1.20 m long and the ends of each line are marked with cones (Indian clubs, blocks, etc).
- Make sure that both feet cross the line each time that he/she remains in the required path and that the turns are made as quickly as possible.
- Call out the number of cycles completed after each cycle.
- The test stops when the subject crosses the finishing line with one foot.
- The subject should not slip or slide during the test, so a slip-proof floor is necessary.

Score

- The time needed to complete the five cycles is the score and written in tenths of a second.

Example: a time of 21.6 sec scores 216.

4. DESCRIPTION OF ANTHROPOMETRIC MEASUREMENTS (1)
(see also Appendix I)

The majority of measurements are taken with the individual standing erect on a level wooden board (100 x 100 3 cm) with a smooth surface. Only the medial calf skinfold is taken in a sitting position.

Height

The height is measured with the individual standing straight against an upright surface, touching it with heels, buttocks and back. The head is oriented with the upper border of the ear opening and the lower border of the eye socket on a horizontal line, heels together and on the board. The subject takes and holds a deep breath and is then measured to the nearest millimetre.

Weight

The subject, wearing minimal clothing, stands in the centre of the scales. Weight is recorded to the nearest tenth of a kilogram.

Skinfolds

For these measurements, a fold of skin and subcutaneous tissue is picked up firmly between thumb and forefinger of the left hand and pulled away from the underlying muscle. The edge of the plates on the branches of the caliper are then applied 1 cm below the fingers of the left hand and allowed to exert their full pressure before reading the thickness of the fold. It does not matter whether the skinfolds are taken on the right or left side of the body, but they must all be taken on the same side. The subject stands relaxed, except for the calf skinfold which is taken with the subject seated. They are measured to the nearest 0.1 mm.

Triceps skinfold

With the subject's arm hanging loosely, a fold is picked up at the back of the arm level halfway on a line connecting the acromion and the olecranon processes.

Biceps skinfold

The skinfold is picked up on the front of the arm, directly above the centre of the cubital fossa, at the same level at which the triceps skinfold is measured.

Subscapular skinfold

The subscapular skinfold is picked up just beneath the inferior angle of the scapula in a direction which is obliquely downwards and outwards at 45 degrees.

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(1) This section is largely based on the works cited in the bibliography: see Appendix III, references 11, 12 and 13. A table for calculating percentage of body fat, from four skinfolds, is at reference 14.

Anterior suprailiac skinfold

The fold is picked up 5-7 cm above the anterior superior iliac spine on a line to the anterior axillary border, and on a diagonal line going downwards and inwards at 45 degrees.

Medial calf skinfold

A vertical skinfold is picked up on the medial side of the leg, at the level of the maximum girth of the calf.

TABLE IX

SCORE SHEET/PROFILE CHART

EUROFIT SERIAL No. .....

AGE GROUP: ..... SEX: .....

SCHOOL: ..... CLASS: .....

NAME: ..... CHRISTIAN NAME: ..... AGE: |_|_|_|_| years months

HEIGHT (cm): |_|_|_|_| WEIGHT (kg): |_|_|_|_|

SKIN FOLDS (mm): TRICEPS |_|_|_| BICEPS |_|_|_| SUBSCAPULAR |_|_| |_|

SUPRAILIAC |_|_|_| CALF |_|_|_|

EUROFIT TESTS	AVERAGE - STANDARD VARIATION	ACTUAL TEST SCORE	SCORE IN RELATION TO REFERENCE SCALES Median 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	
1. "FLAMINGO" BALANCE				
2. PLATE TAPPING SPEED OF LIMB MOVEMENT				
3. SIT AND REACH FLEXIBILITY				
4. STANDING BROAD JUMP EXPLOSIVE STRENGTH				
5. HAND-GRIP STATIC STRENGTH				
6. SIT-UPS TRUNK STRENGTH				
7. BENT ARM HANG FUNCTIONAL STRENGTH				
8. SHUTTLE RUN 50 m RUNNING SPEED/ AGILITY				
9. ENDURANCE SHUTTLE RUN				
BICYCLE ERGOMETER TEST CARDIO-RESP. ENDURANCE				

PART III: Appendices

A P P E N D I X I

Materials required for the EUROFIT tests

1. ENDURANCE SHUTTLE RUN TEST

- A gymnasium or space sufficiently large to mark out a 20 metre track (minimum space between pupils should be one metre);
- a tape measure (20 metres);
- self-adhesive tape to mark the 20 metre lines;
- a tape recorder, preferably allowing adjustment to the turning speed of the tape;
- a pre-recorded tape with a recording of the protocol.

2. BICYCLE ERGOMETER TEST (PWC170)

a. Bicycle ergometer:

i. mechanically braked by a friction belt, tensioned by suspended weights or pendulum system. Accurate calibration and adjustability of resistance is essential;

ii. fitted with a pedal revolution meter;

iii. suitable for the size of the child being tested (for example most adult stationary bicycles are not suitable for children less than 1 m 35 or so in height). Adequate adjustment of saddle and handle bars should be provided. For small children pedals with a simple toe strap are preferable.

b. Stopwatch and a stethoscope for heart rate measurement. Other equipment eg heart rate meters, should be checked for reliability.

c. Clock.

d. Weighing scales (kilograms).

3. MOTOR TESTS

Flamingo balance

A wooden or metal beam, 50 cm long, 4 cm high, 3 cm wide, stabilised by means of two supports, one at each end, 15 cm long and 2 cm wide. The top surface of the beam can be covered with a soft material, eg felt or mock-velvet, to make it more comfortable.

Hand grip

Hand dynamometer, calibrated in kilograms.

Plate tapping

A table, c 120 cm x 40 cm, adjustable in height. Two rubber discs, 20 cm Ø. One rectangular plate, 10 x 20 cm.

Sit and reach

A table or box, 35 cm long, 45 cm wide, 32 cm high, with a superposed top plate 55 cm long, with a scale 0-50 cm marked on it (eg every 5 cm).

Standing broad jump

Non-slip hard surface - eg, 2 judo or gym mats set end to end. Chalk; tape measure.

Sit ups

Non slip hard surface - eg 2 judo or gym mats set end to end.

Bent arm hang

Horizontal bar, 2.5 cm Ø, set ±190 cm above the ground.

Shuttle run: 10 x 5 m

Slip-proof floor. Tape measure. Chalk or white self-adhesive tape. Four traffic cone or similar markers.

Additional materials:

Tape measure:

- Endurance shuttle run (up to 20 m).
- Standing broad jump.
- 10 x 5 m shuttle run.

Stopwatch:

- Flamingo balance (without reset).
- Plate tapping.
- Sit-ups.
- Bent arm hang.
- 10 x m shuttle run.
- [Bicycle ergometer test].

Traffic cones:

- 10 x 5 m shuttle run.

Self-adhesive tape (or chalk):

- Standing broad jump.
- 10 x 5 m shuttle run.
- Endurance shuttle run.

Judo or gym mats:

- Standing broad jump.
- Sit-ups.
- [10 x 5 m shuttle run].

4. MEASUREMENT INSTRUMENTS

Anthropometer (Martin) (1)

Used for the measuring of stature. To help maintain the anthropometer in a vertical position, the lowest segment is inserted into a specially constructed baseplate. The baseplate is made of plastic, 80 x 80 x 12 mm, with a vertical cylinder 40 mm long and 30 mm in diameter set into one corner of the baseplate. The internal diameter of the cylinder is drilled to match the diameter of the anthropometer which is secured in position by a thumb screw through the cylinder wall. (Baseplate designed by Dr. W D Ross, Simon Fraser University).

Stadiometer (Ross) (1)

A Parallax-correcting stadiometer consisting of a clear plastic manufactured Broca plane, which is designed to slide vertically on a piece of wood (approximately 5 x 10 x 230 cm), and an anthropometric tape. A groove in the backplate permits passage of an anthropometric tape which is taped to the vertical face of the wood at a calibrated level. Reading is facilitated by a double scratchline on the backplate.

Stadiometer (Harpenden) (1)

The Harpenden Stadiometer (digital read-out; wall-mounted) is recommended for use in more permanent anthropometric laboratories. It consists of an upright light alloy frame, provided with adjustable wall brackets for mounting, and a head block which operates via miniature ball-bearing rollers to give a movement which is free yet without cross-play. The measurement range is 600-1200 mm. A portable stadiometer is also available, range 850-2060 mm. In field studies stature may also be measured with an anthropometer (see above).

Skinfold calipers (Harpenden, Holtain or cheap plastic calipers)

The Harpenden and Holtain calipers (1) have a constant pressure of 10 g/mm2 exerted by the jaw surfaces at all openings. They are designed for research purposes.

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(1) Necessary only for survey purposes.

The cheap plastic calipers are not designed to provide an accurate instrument for scientific purposes, being aimed at the general practitioner market. Before using such calipers, check if it was validated against the more accepted calipers described above.

Beam balance scale

A beam balance scale should be used for determining body weight in kilograms and 0.1 kg. If a spring balance is used its accuracy should be checked from time to time.

A P P E N D I X II

PROFILE CHARTS

Table IX at p. 46 gives an example of a profile chart which can be used as a diagnostic tool in assessing physical fitness. Profile charts are useful to obtain a quick view of the general physical fitness of a single subject or a group of subjects. The result in one test or measurement can be easily compared with other tests. Profile charts should be constructed for each national sex and age group separately on the basis of national reference values. Children between 6 years and 7 years are considered as 6 year olds; those between 7 and 8 years as 8 year olds, etc. The national reference values for each sex and age group need to be constructed on a scale ranging from 0-20 on the basis of data from a nationwide representative sample of the entire school population.

A scale ranging from 0 to 20 was chosen since such a scale is often used in schools and it provides enough differentiation for all the components of physical fitness. The scale is so arranged that the P 50 value will be exactly at 10.0 with the two limiting classes being 0 and 20. In Table X the exact limits of the 21 units in terms of percentile scores are given (1).

Table X: Scores on the EUROFIT tests and the corresponding limits of the percentile scores

Eurofit test score	Limits of the percentile score (P)	Percentage within each class
20	P 99.1	0.9
19	P 98.3	0.8
18	P 97.0	1.3
17	P 94.8	2.2
16	P 91.5	3.3
15	P 87.0	4.5
14	P 80.9	6.1
13	P 73.4	7.5
12	P 64.6	8.8
11	P 55.0	9.6
10	P 45.0	10.0
9	P 35.4	9.6
8	P 26.6	8.8
7	P 19.1	7.5
6	P 13.0	6.1
5	P 8.5	4.5
4	P 5.2	3.3
3	P 3.0	2.2
2	P 1.7	1.3
1	P 0.9	0.8
0		0.9

(1) If the test scores in the population follow a normal distribution, each class contains 0.25 standard scores.

Appendix II

The P-values refer to percentiles of the distribution of test scores. Thus 55% of the test results in the total population are situated under a P 55-value. Thus, a score of 10 is given when the test result of a subject is situated between P 45 and P 55 which means that this score is obtained by those 10% of the children who perform better than 45% of the population and less well than (100-55) = 45% of the population. Similarly a score of 15 is given when the test result of a subject is situated between P 87 and P 91.5 which means that this score is obtained by those 4.5% of the children who perform better than 87% of the population and less well than (100-91.5) = 8.5% of the population.

Individual test scores can be plotted on these charts and the points connected. This "profile" gives an overall picture of a subject in relation to his or her age group. In this way individualised interpretations can be made and one can quickly see in which test or measurement the subject ranks above or below the median for his or her age group.

However, in interpreting the results, one must take into account that each measurement or test result is affected by a measurement error. Small differences in the location of test results should therefore be ignored. Each test in the motor test battery measures a separate factor, so low correlations should be expected.

These charts can also be used to compare average measurement and performances of a group or groups of subjects to the national reference values. Such comparisons can provide useful information about the location of the average physical fitness test results of a school class, a sports team or any other group. In this way, good or average performances can be detected and teaching objectives and training programmes could be modified accordingly.

A P P E N D I X III

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APPENDIX IV
ANNEXE IV

LIST OF PARTICIPANTS AT THE EUROPEAN RESEARCH SEMINARS ON TESTING PHYSICAL FITNESS
(Paris (1978), Birmingham (1980), Leuven (1981), Olympia (1982) and Formia (1986)

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