International Symposium
on
Sport for all !

MILITARY FITNESS: BASIC DATA TO RE-EVALUATE THE FITNESS CONCEPT IN THE AUSTRIAN FEDERAL ARMY

COL DR P. WITTELS (AUSTRIA)

If sports for all and effects of exercise on health and well-being, settled in an environment of armed forces, are discussed, than also some aspects of military fitness have to be mentioned. In many countries, as well as in Austria the concepts of military fitness are currently under re-evaluation (11).

The Research Study Group on Physical Performance is an interdisciplinary working group. It was founded in 1991 to perform investigations with regard to an updated, scientific basis for new concepts in military fitness and a better understanding of psycho-physiological regulations during military missions. The Study Group works predominantly based on the infrastructure of the Army Hospital and the Military Sports&Close Combat School in Vienna. The military units involved in the Study Group are the Performance Medicine&Military Ergonomics Division, the Military Sports&Close Combat School, the Special Forces Training Center and the Infantry School, and there especially the alpine instruction staff. The Research Study Group also cooperates with the Universities in Austria and in some foreign countries. Additionally exists in- and output with a mixed military and civilian scientific board at the Ministry of Defense. With a mobile research unit it is possible to perform the studies on the scene of action during the military training (7). The results are proceeded to the Ministry of Defense and will there be transferred into consequences for the soldier.

When discussing military fitness one should first ask, if there are differences in the demands of the military system and the individual soldier with respect to fitness. The demands of the system could be summarized as: „We want fitness to perform adequately". To illustrate the demands of the individual soldier a questionnaire in 142 conscript-recruits of an infantry regiment in Vienna revealed the following results:

- 92 % thought, that regular sports for health benefit is important
- 68 % were motivated to perform sports regularly
- 58 % expected improvement of fitness during basic military service
- 5 % expected primarily sports during basic military training

Warendorf - Germany
22 - 28 September 1996

With respect to testing and training fitness the conditions given by the system seem to be: „As easy and cheap as possible, but as precise as needed". As a consequence of the above mentioned questionnaire's result there has to be added the recommendation that the system should take the chance to deal adequately with expectations and motivation of soldiers.

Under these premises we started the re-evaluation of testing and training. The main topics with regard to testing were:

- Description of the physical strain during military training
- Definition of minimal requirements for physical fitness
- Establishment of adequate test procedures

With regard to training, the studies should lead to guidelines according to requirements, expectations and health benefit.

Therefore we started monitoring the strain in different military activities with special regard to endurance. During the training the soldiers were investigated beside other measurements (3,4,9,12), by continuos heart rate (HR) monitoring. This was done with a sport-tester PE 4000 (Polar Electro, Kempele, Finland) and was based on beat-by-beat ECG measurement with HR transmission by telemetry. The signal was computed in the sensor-transmitter and was transmitted to a wristwatch-like receiver microcomputer. The accuracy of HR-monitoring using the sport-tester was assessed by simultaneous HR and ECG recording during CE. The HR was recorded beat-by-beat, the mean HR of every 60-s interval being stored on the receiver microcomputer. Immediately before and after the stressful military tasks of the combat training, the soldiers pressed the marker button at the wristwatch-like receiver. After the events the HR recording was transferred via the interface unit to a PC for analysis (10). The sport-tester PE 4000 is shown in Figure1.

As an example for a profile of physical activity during military training a 5 day lasting survival training is demonstrated in Figure2. The X-axis represents the hours of training, the Y-axis represents the exercise intensity during this week. The exercise intensity during the training was expressed in this graph as a percentage of the maximal heart rate achieved during a maximal cycle ergometry (CE). There were only short periods during tactical missions and guerrilla training which were around or above the anaerobic threshold, which means periods with a lactate concentration of 4 mmol/l or more.

In Figure3 a further example of monitoring a military training is given. This was a combat competition which consists of marching 32km interrupted by 6 military tasks. The exercise intensity (EI) of this training is demonstrated in the lower part of the graph. The EI ranged between 35 and 60 % of the maximal aerobic work capacity of the subjects.

Based on findings as demonstrated it could be concluded that military training is:

- Predominantly below the aerobic threshold (serum-lactate<2mmol/l), with short periods at/or above the anaerobic threshold (serum-lactate≥4mmol/l).
- HR controlled military exercise can effectively train endurance, but the commanders have to be informed about the basic principles of training and have to be aware of the right dosage of activity and rest periods.
- The commanders have to know, that the reliability of HR-control is limited to thermoneutral conditions, moderate altitude etc.

The evaluation of our studies lead to the evidence that the minimal requirement of aerobic capacity for infantry soldiers is 3.5 W/Kg (8). This value equals an estimate of 45 ml/min/kg of maximal oxygen uptake ($VO_{2,max}$), which is in parallel with the requirements defined in a NATO co-operative study on physical fitness published in 1986 (2).

A performance of 3.5 W/Kg can be achieved by 2.5 to 3 hours of endurance training per week. This training time is identical with the most effective amount of training which can be recommended for health benefit, as it will be explained below.

A performance of 3.5 W/Kg can be achieved by 2.5 to 3 hours of endurance training per week. This training time is identical with the most effective amount of training which can be recommended for health benefit, as it will be explained below.

Figure4 demonstrates the result of one of the important epidemiological studies of Paffenbarger (5). The graph shows the percentage-reduction in risk for developing the first attack on coronary heart disease. The X-axis represents the energy expenditure by physical activity (vigorous sports) per week expressed as kcal/week. The Y-axis represents the percentage-reduction for the first attack of coronary heart disease. The most effective portion in risk reduction is achieved with an energy expenditure between 500 and 2500 kcal/week exceeding a sedentary life-style by vigorous sports. And it also demonstrates that additional energy expenditure by sports adds only a few percent of additional risk reduction.
Taking into account the recommended training time per week to develop and maintain sufficient military fitness it can be calculated:

- 1hour of endurance training with moderate intensity leads to 800 kcal of energy expenditure
- this done3 times per week results in an energy expenditure of about 2400 kcal/week by training endurance.

Thus, it can be concluded, that training sufficient to meet military requirements and criteria of health benefit are identical.

If the desired 3.5 W/kg are expressed as a percentage of the average maximal work performance in healthy but sedentary male Austrians (figure5), than what does this mean with respect to age? The maximal work performance of a 20 year old male meeting this criterion is about 11% higher than the average Austrian male with sedentary life-style. 3.5 W/kg in a 50 year old male means being 45% above the average.

As the next step selected groups of soldiers were screened for their physical performance. All tests in the study were performed by cycle ergometry (CE). The maximal work capacity was assessed for each subject on a computer controlled cycle ergometer Ergo-metrics 800S (Ergoline, Blitz, Germany). This ergometer possessed an eddy current brake, with measurement of rotational moment, independent of rotational speed. The range of exercise intensity was 25–990 Watt (W), measured with an accuracy of 2%±3W. The subjects started with an initial exercise intensity of 50W over 3min. Every 3min exercise intensity was increased by 50W until the subjects were unable to continue due to exhaustion (vita maxima test; "all out"-test). The highest exercise intensity achieved at exhaustion was recorded as W_{max} and was then used to calculate W_{max}/kg. The $VO_{2,max}$ was estimated by the regression equation described by Storer et al.(6). All calculations for the cycle-ergometer test were done with the aid of a computer software (10). The HR-monitoring was done with an electrocardiogram and/or with a sport-tester PE 4000 as described before. The maximum heart rate (HR_{max}) achieved at exhaustion in CE was used as the reference value for the individual's HR_{max}.
The results of the maximal aerobic work capacity of the tested soldiers are presented in the table.

	N	MW [W/kg]	SD
Infantry	143	3,4	0,4
Rangers	53	4,4	0,5
NCO-Aspirants	131	3,9	0,6
Mountain Guides	83	4,2	0,6
Med. Sold.	45	3,5	0,7
Med. Alpine Sold.	34	3,9	0,7
Mil. Perform. Athletes	10	4,4	0,5

These results seem to fit the requirements, but were biased by the fact that only soldiers participated who were declared fit for service without any major medical restrictions. For example, of the infantry recruits about one third had medical restrictions and thus, were not cleared to perform an "all out"-test.

It has to be mentioned that CE is not a method for mass screening during routine.
But, if endurance is essential for military performance and health benefit, than reliable and valid test procedures also applicable during routine are imperative. Thus, we re-evaluated endurance test procedures used in the Austrian Army.

Figure6 shows a theoretic model dealing with the reliability and predictability of test procedures in general. This model was especially adapted to discuss endurance testing. The horizontal red line marks the boarder of the minimal requirements of job specific field endurance in the military. The vertical red line is the border between failing and passing an endurance test. So the ideal and desirable result of any test procedure would be to produce only true positive and true negative results. But this desire does not represent reality. It is not realistic to expect no false positive and no false negative results. We can only try to keep the area of false positive and false negative results as small as possible by establishing adequate test procedures. A false positive result means somebody passes the test but fails during his job-specific demands in field endurance leading to a waste of time and money in training this soldier. A false negative result means that a soldier was not able to pass the test but could have performed adequately during field endurance. Such a test result would be at least unfair if the career is depending upon such a test procedure. Additionally it is a waste of resources in personnel.

Based on that theoretic model considerations were made about endurance test procedures for the use in daily military practice. The applicability of a test as a routine procedure is determined by the overall expenditure in time, equipment and personnel. A further decision is required with respect to submaximal or maximal test procedures. Submaximal test procedures have the advantages to be safer with regard to major medical complications. Additionally submaximal tests mostly require less amount of time than maximal tests. But maximal test procedures are more reliable and valid. The major disadvantage in submaximal tests is, that the result has to be extrapolated for estimating the maximal work capacity. Both types of tests should be applicable without individual specialization and should be performed under standardized conditions.

Under these premises routine procedures for testing endurance were checked.
The 2400m-run (a reversed Cooper test; identical with the 1.5mile-run) is used as a screening test in all soldiers in Austria. The CE is used in limited groups for special military training or medical investigation. Both test procedures have to be performed as a maximal, so called "all out test". The CE has an accepted reliability and validity. Thus, CE was used in our studies as the reference in the correlations between CE-results in W/Kg and the results in seconds of the 2400m-run (Figure7).
In 294 soldiers the correlation was highly significant. According to this correlation a running time of 10min:30sec, which is a minimal requirement in different military training's, equals a mean maximal work capacity of 3.7W/kg. In a further group of 111 recruits both test methods were applied (Figure8). One of the questions with regard to the reliability of the 2400m-run under routine conditions was, as to weather the range of results in W/kg will be in a running time of 10min:30sec? As shown in Figure9 the mean result for a running time of 10min:30sec was 3.7W/kg, but with a range between 3.0 and 4.1W/kg. This result demonstrates, that with the 2400m-run a group meeting the above mentioned minimal requirement reliably could be identified, but when individuals were classified a certain percentage of false positive results were present.

A further example to demonstrate the problem of false positive and negative results in test procedures is given by results of the "PWC 170"-test. This widely used test measures the physical work capacity (PWC) at a heart rate of 170/min and estimates the maximal work capacity from this result. Figure10 demonstrates four groups of different fitness level. The PWC 170 is reached in the mean at 70% of the maximal work capacity in all four fitness-groups. But for example in the fitness-group of "3-3.5 W/kg" there were also individuals reaching their PWC 170 at 47% and at 91% of their maximal work capacity. This result proofs also for PWC 170, that it is a reliable test procedure to classify groups but can be extremely misleading when rating individuals. A range between 47% and 91% demonstrates clearly , that extrapolation from PWC 170 to the individuals maximal work capacity can be extremely over- or under-estimating.

Conclusions

There is evidence of the necessity to continue with the evaluation of exercise intensity during military strain, to define more job specific minimal requirements, to protect the individual and to ensure job performance. There is further evidence of the necessity to use reliable test methods and to improve the resources to make them applicable. For the individual soldier there is the possibility of training endurance save and effectively also during military training and to be motivated not only to train for the job but also for health benefit. The application of reliable tests can deliver information about job-performance and health status, leading to training guide lines according to the scientific standards. The soldier can be more effectively coached and thus, feel himself well treated. The results of the different studies performed should undergo troop-trials under routine conditions and than be imbedded in the guidelines for military service. The commanders should be obligatory advised by qualified personnel about the scientific principles of training and the advantages but also limits of the applied methods.

Acknowledgement

The studies received a grant of the Austrian Ministry of Defence, BMLV ZL.65.505/43-5.2/92. The views, opinions, and/or findings contained in the report are those of the authors and should not be construed as an official position of the Austrian Ministry of Defense, unless so designated by other official documentation. We would like to thank all the recruits of the Research Study Group on Physical Performance since 1992 for their technical assistance performing the studies and especially R.Ghasemipour and R.Schmauser preparing the present manuscript. Based on the data of the different studies performed two master theses and one doctoral thesis at the Institute of Sports Sciences of the University of Vienna are under preparation.

****

REFERENCES

1. Arbeitsgemeinschaft für Ergometrie der Österreichischen Kardiologischen Gesellschaft (1978) Leitlinien der Ergometrie. Öst Ärzteztg 33/7: 333-344

2. Defence Research Group - Panel on the Defense Applications of Human and Bio-Medical Sciences - Research Study Group on Physical Fitness: Physical fitness in armed forces; Final report. NATO Unclassified Document (1986).

3. Gunga H Chr, Kirsch K, Baartz F, Steiner HJ, Wittels P, Röcker L (1995) Fluid distribution and tissue thickness changes in 29 men during one week at moderate altitude (2 315 m). Eur J Appl Physiol 70: 1-5

4. Gunga H Chr, Wittels P,Günther Th, Kanduth B, Vormann J,Röcker L, Kirsch K (1996) Erythropoietin in 29 men during and after prolonged physical strain with food and fluid deprivation. Eur J Appl Physiol 73: 11-16

5. Paffenbarger RS, Hyde RT (1984) Exercise in the Prevention of Coronary Heart Disease. Prev Med 13: 3-22

6. Storer TW, Davis JA, Caiozzo VJ (1990) Accurate prediction of VO2max in cycle ergometry. Med Sci Sports Exer 22: 704-712

7. Wittels P (1993) Der Mensch und die Extrembelastung: Leistungsmedizin-Belastungsmedizin. Öst Ärzteztg 48/21: 32-35

8. Wittels P, Rosenmayr G (1994) Regulationen bei Stress und körperlichen Belastungen unter extremen Umweltbedingungen. Rettungsdienst 17/1: 34-37

9. Wittels P, Rosenmayr G, Bischof B, Hartter E, Haber P (1994) Aerobic fitness and sympatho-adrenal response to short-term psycho-emotional stress under field conditions. Eur J Appl Physiol 68: 418-424

10. Wittels P, Manchen G, Stockinger A, Haber P (1995) Computergestützte Auswertung der Fahrradergometrie zur Dosierung des Ausdauertrainings im Gesundheitssport. Wien Klin Wochenschr 107/6: 188-194

11. Wittels P, Zeilinger M (1995) Fitness-Training im Grundwehrdienst: Pilotstudie zur Reevaluierung der Körperausbildung im Österreichischen Bundesheer. Wehrmedizin u. Wehrpharmazie 19/1: 10-12

12. Wittels P, Gunga H Ch, Kirsch K, Kanduth B, Röcker L (1996) Fluid regulation during prolonged physical strain with water and food deprivation in healthy, trained men. Wien Klin Wochenschr: in press

Correspondence:
Colonel Dr. P.Wittels
Performance Medicine & Military Ergonomics Division
Army Hospital Vienna
Brünnerstraße 238
A-1210 Vienna/ Austria

Phone: 0043 - 1 - 291 16 - 2212
Fax: 0043 - 1 - 291 16 - 2213

Figures: The description of the figures is given in detail in the text.

Figure1: Sporttester PE 4000 (Polar,Kempele,Finland)

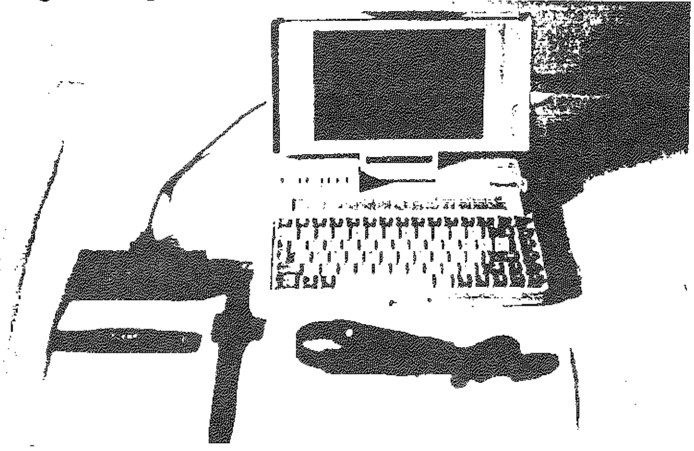

Figure2

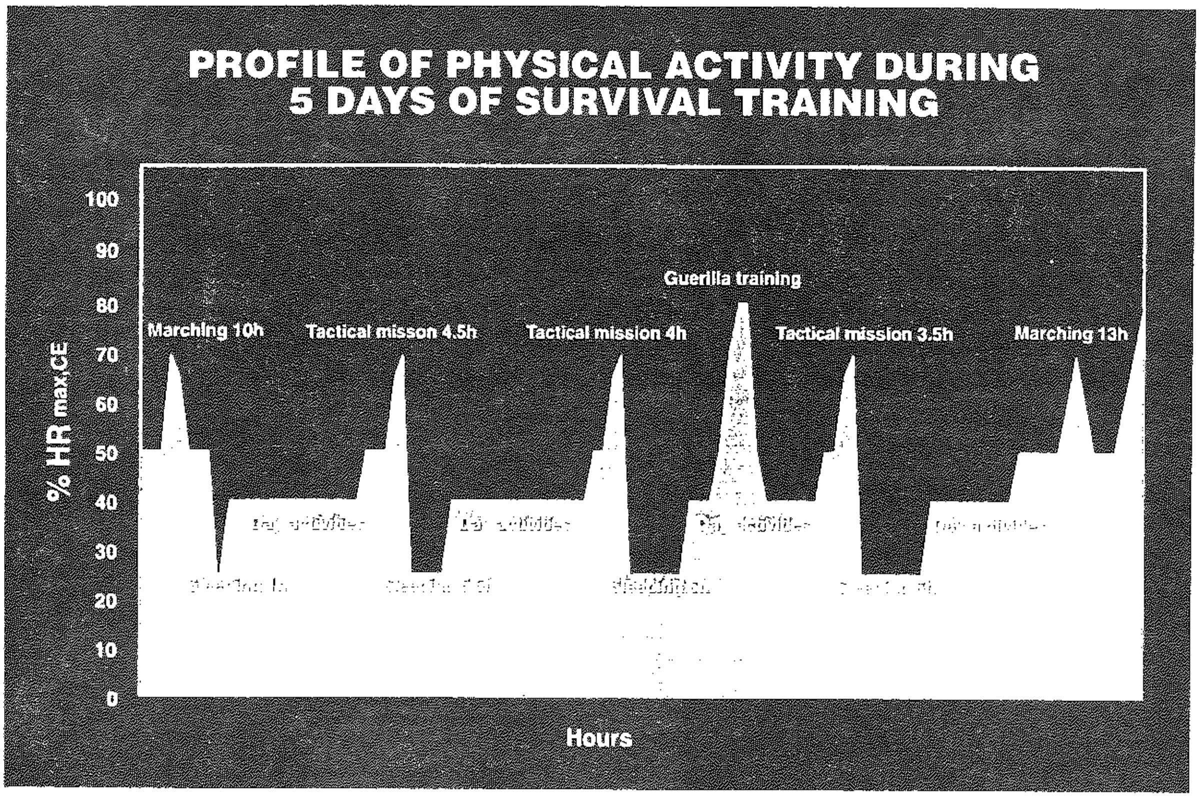

Figure3

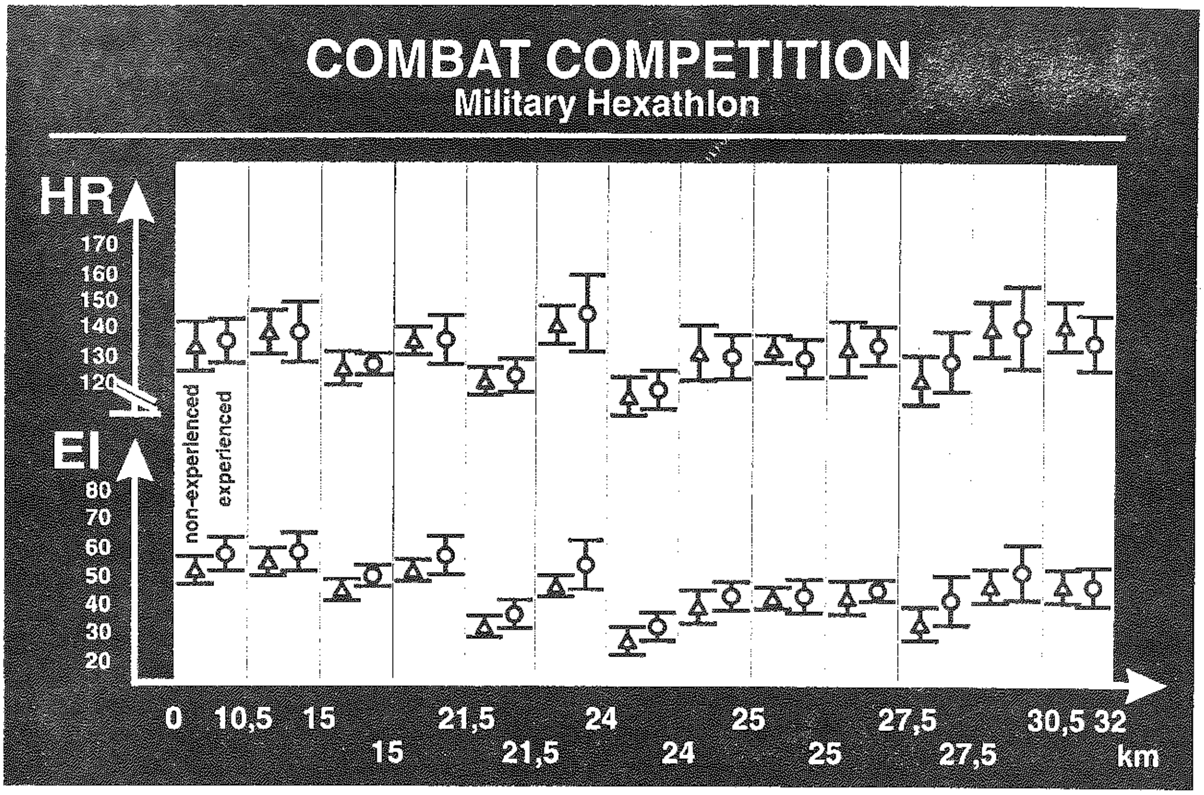

Figure4

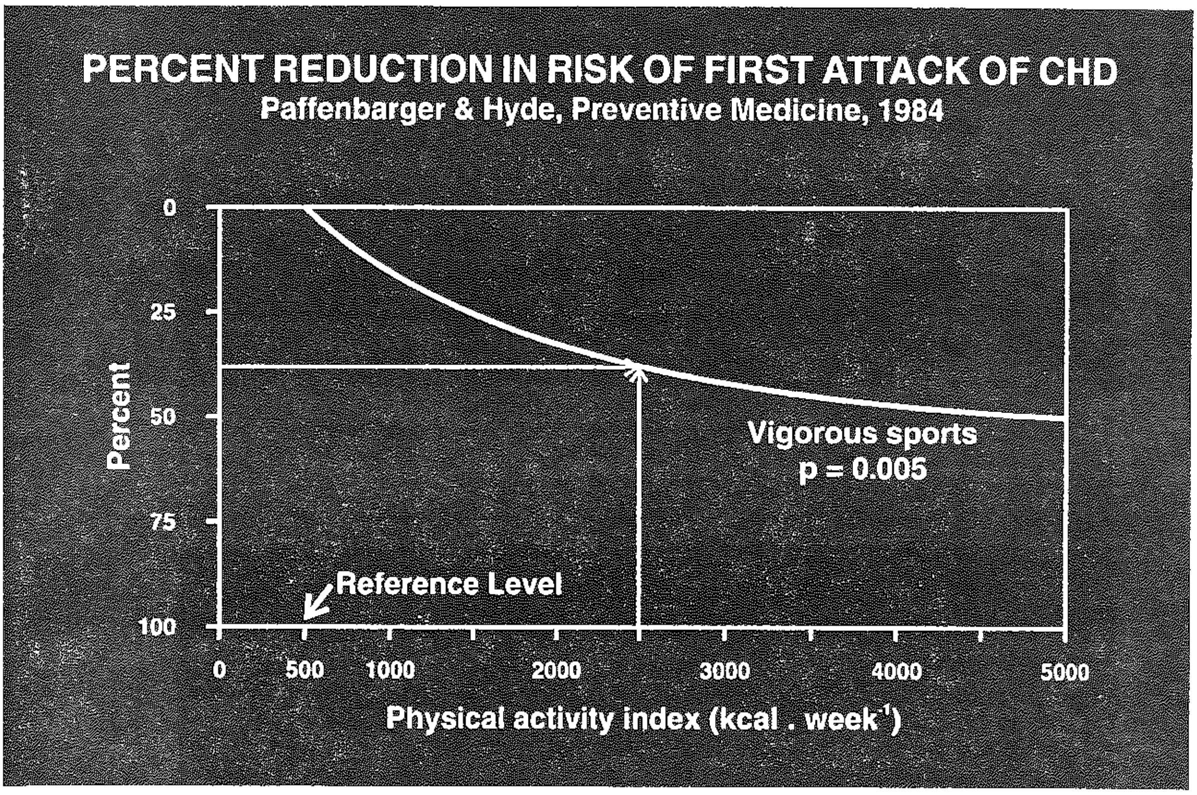

Figure5

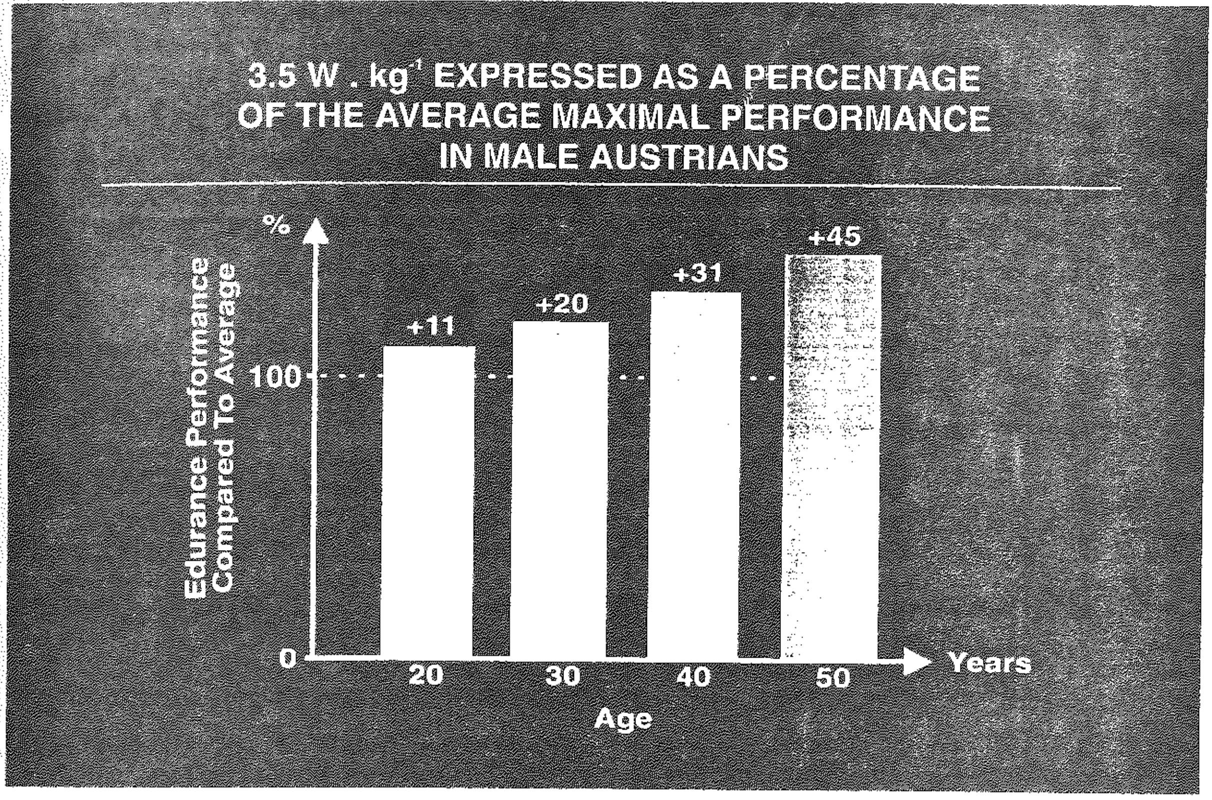

figure6

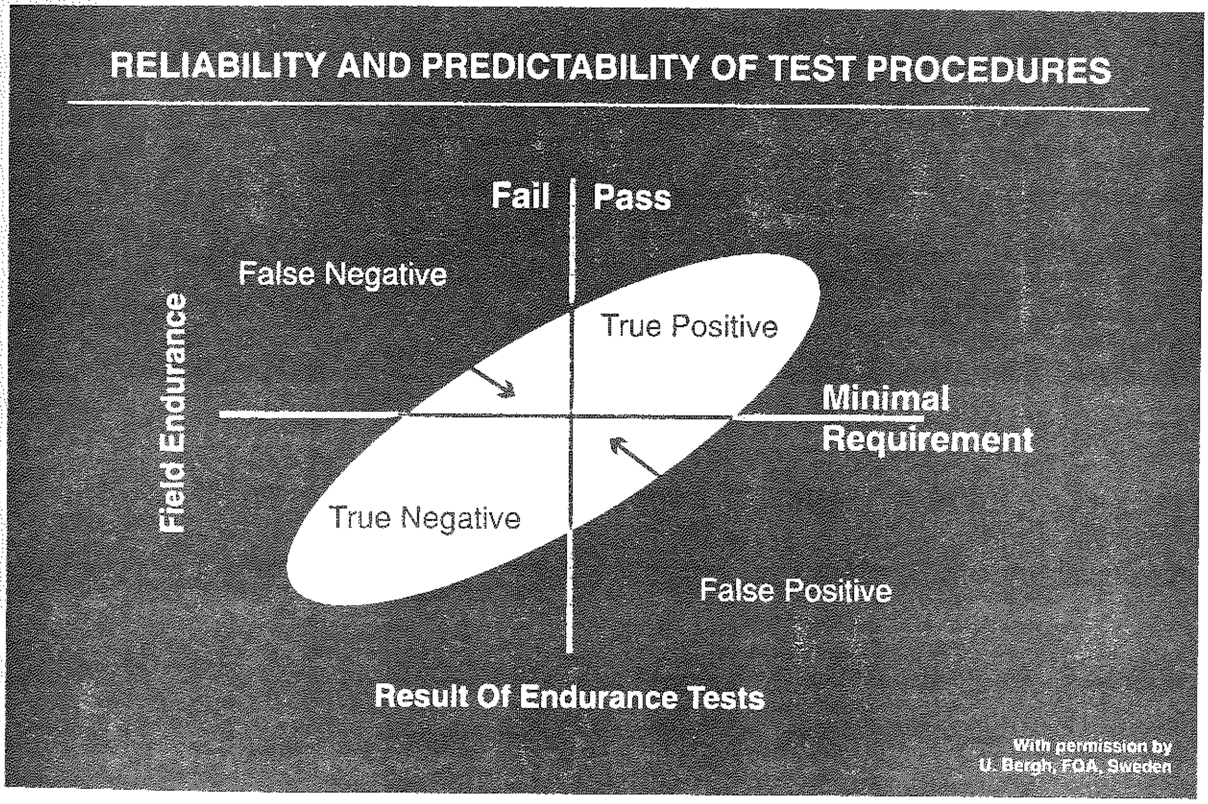

Figure7

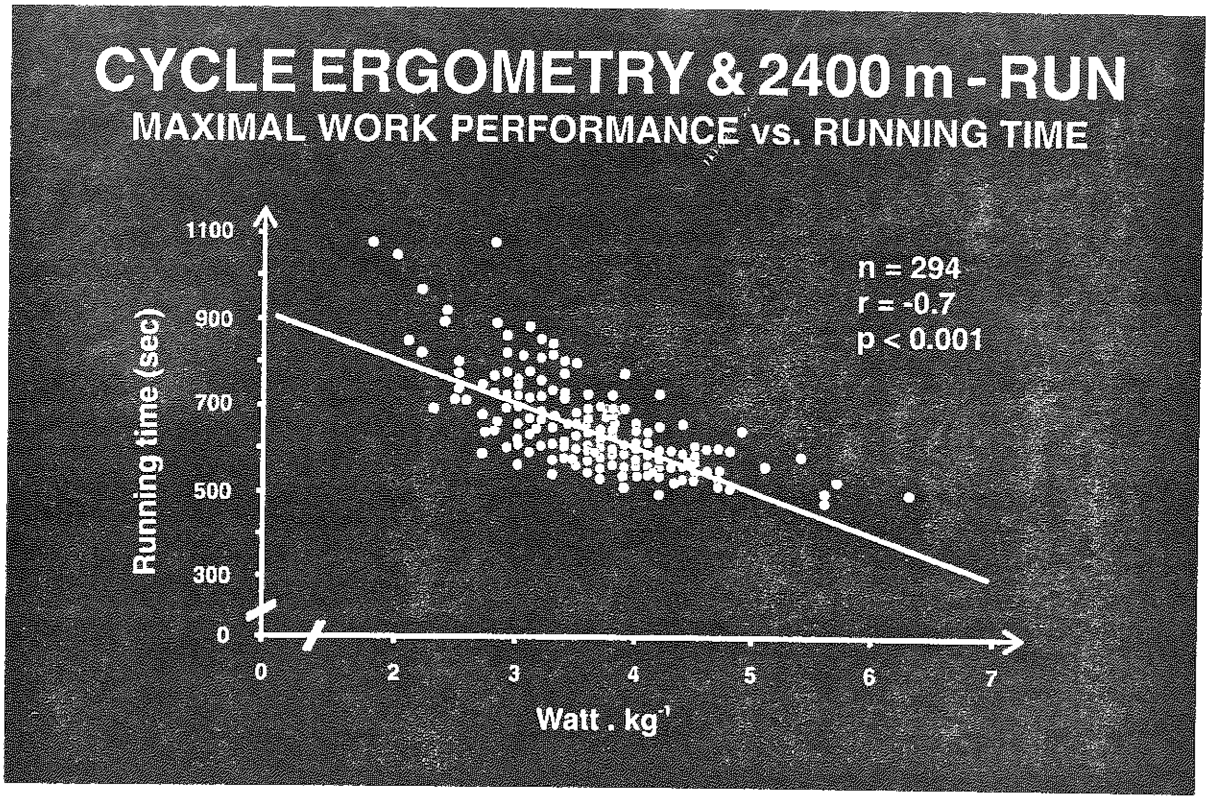

Figure8

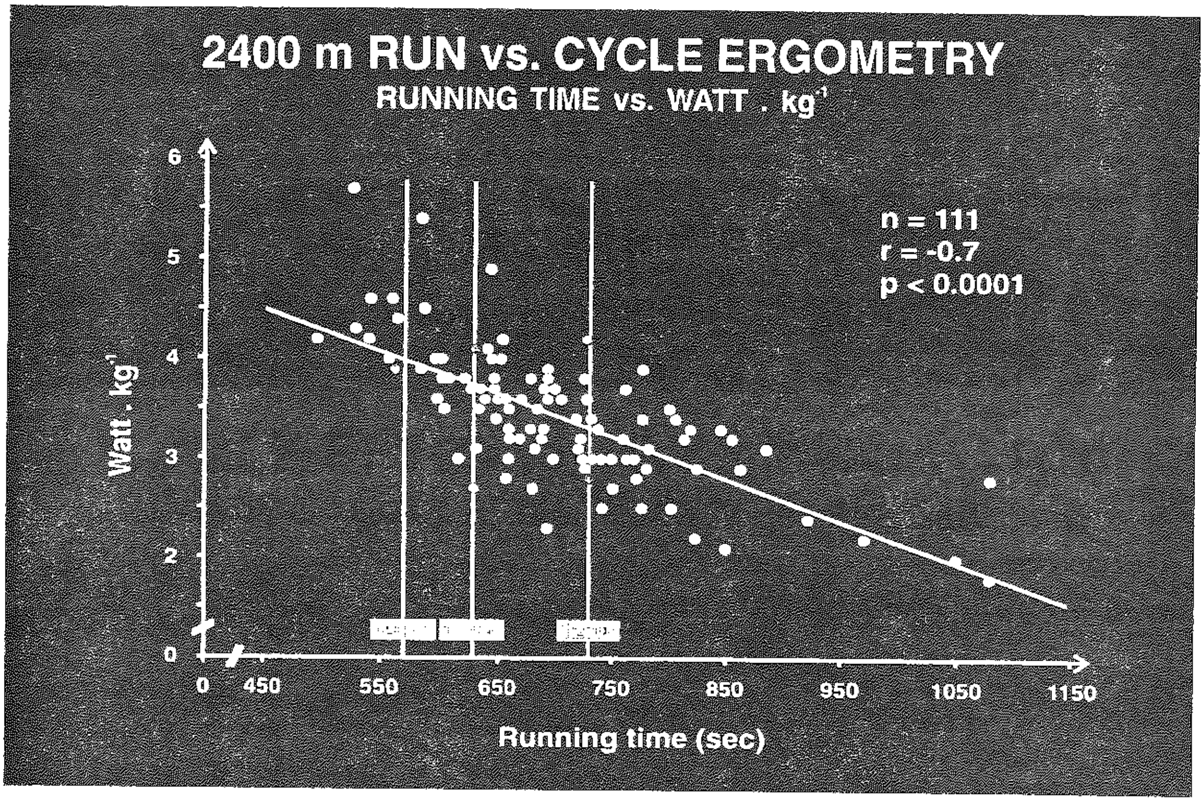

Figure9

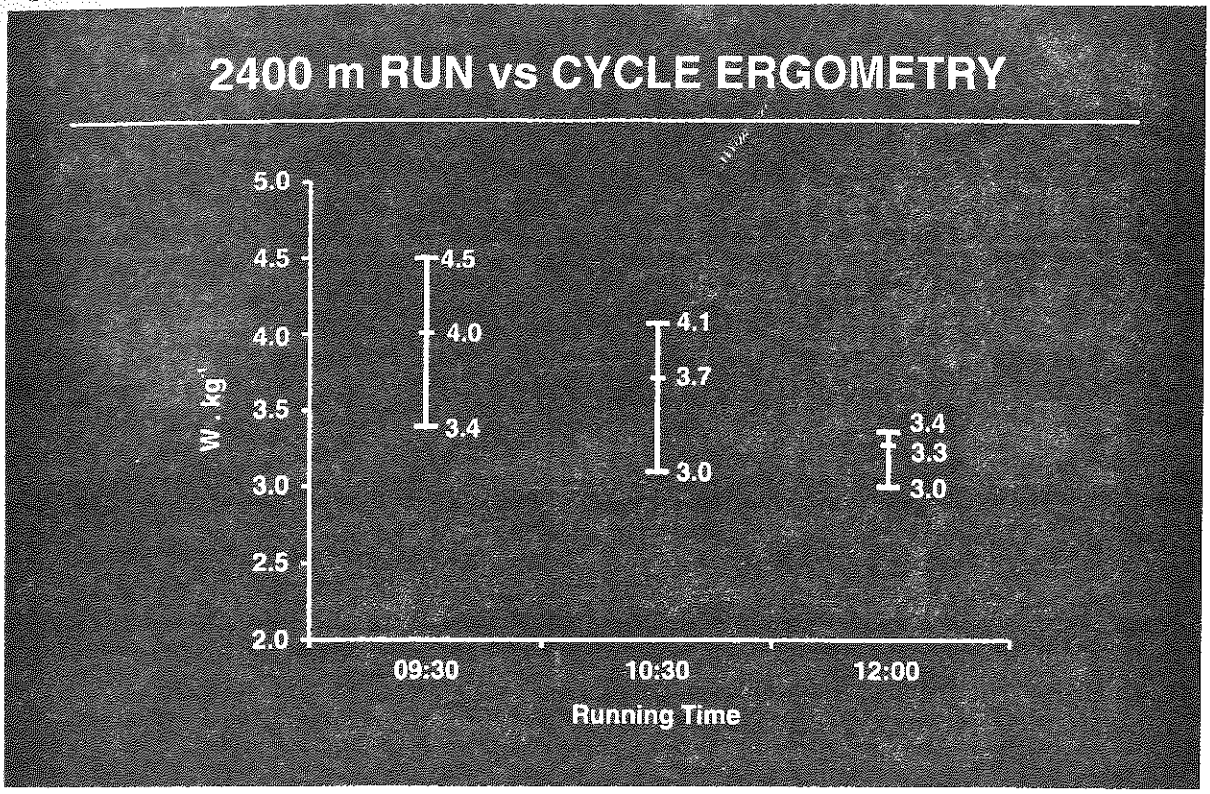

Figure10