Chapter 8 – Physiological testing

In this chapter we describe the physiological tests that have been developed and used with BOF teams. The tests have been developed with the following aims:

1. Provide information on which types of aerobic training should be prioritised.
2. Give a basis for optimising training with respect to volume and intensity.
3. Investigate where improvements due to training have taken place.

Maximal aerobic capacity (VO_2max) is mainly a product of the heart ability to supply the musculature with oxygenated blood. This capacity is often referred to as a central capacity. VO_2max is tested on a treadmill with steadily increasing speed and gradient during 6-8 minutes. Lung ventilation and the amount of oxygen taken up is measured every 10 seconds during the test. These values give the volume (V) of oxygen (O_2) taken up per minute (VO_2). When VO_2 no longer increases despite increased gradient and/or speed VO_2max has been reached (Fig 8). The validity of VO_2max as a single variable for explanation of running perfor-mance for orienteering is however low.

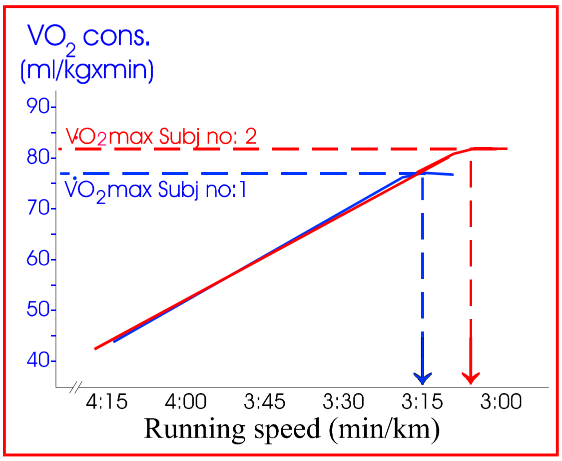

Fig 8. Increase in VO_2 with time on a treadmill for two individuals with different VO_2max values. Individual number 1 reached a max of 74.9 ml/kg x min while individual number 2 reached a max of 80.2 ml/kg x min, which meant that individual 2 could keep running at a higher power output and kept going for approx 70 seconds longer.

During the BOF project the relationship between VO_2max and average running speed on a marked test circuit was established in three different terrain types and for three different courses. In fig 9 the result from a representative standard course in Portugal is shown. The result shows that there is only a weak relationship and, consequently, a low explanation (r^2) for the VO_2max on the mean running competition speed. This means that in this group with runners having relatively high VO_2max values, VO_2max can only explain about 10% of the differences in running performance between the male runners and about 27% of the differences for the female runners. (Fig 9).

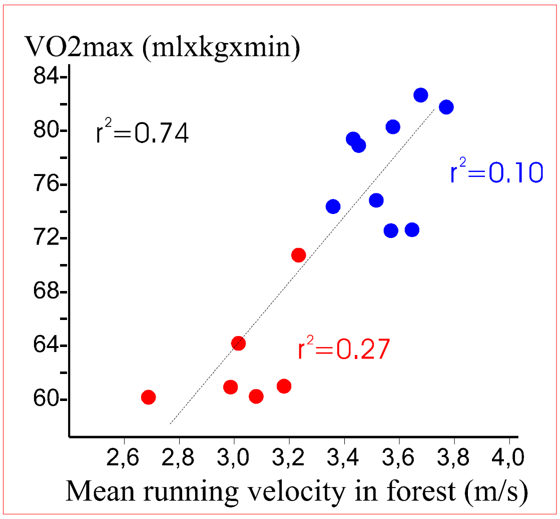

Fig 9. The relationship between VO_2max and average running speed during a simulated competition on a marked course for 15 runners. Red dots denotes female runners and blue dots male runners.

Running performance with the two groups was therefore respectively 90% and 78% unexplained when VO_2max was used as a single explanation variable (Fig 10).
Expressed in running speed the VO_2max test could only explain the forest running performance with an average error of ±44 sec/km. The validity of the VO_2max can, consequently, be concluded to be far too low to use as a single variable for training evaluation and training prescription in elite athletes.

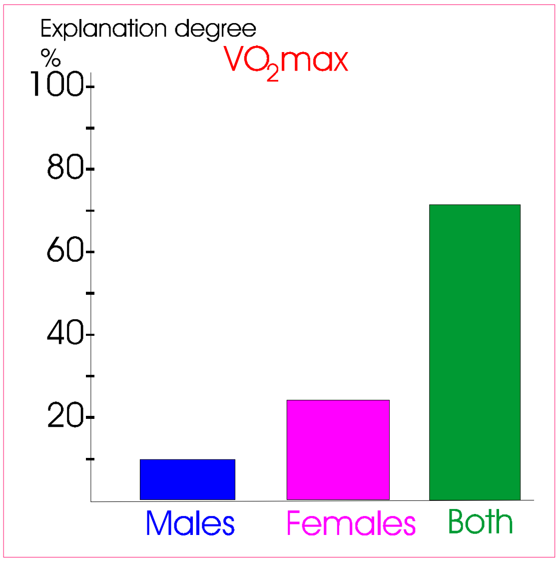

Fig 10. Description of the level of explanation that VO_2max gives for running performance during a simulated competition on a marked course in terrain.

Aerobic running economy/effectiveness, describes the ability of the muscles to use oxygen in an economical way. This capacity is often referred to as a local capacity (3). Running economy is tested during an incremental speed test with 4-5 stages each of 8 minutes. The speed within each stage is constant. Individuals with poor running economy use more oxygen at a given running speed than individuals with good running economy (Fig 11).

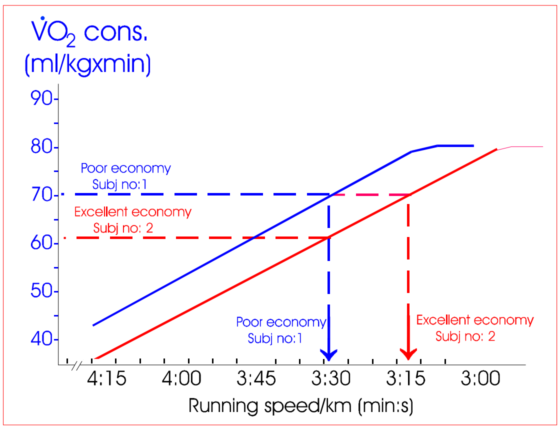

Fig 11. The difference in VO_2 consumption at the same running speed for two subjects. Subject no:1 (blue) showed poor running economy, requiring a VO_2 of about 70 ml/kgxmin at 3:30 min/km speed compared with subject no:2 (red) who showed good running economy and required a VO_2 of 62 ml/kgxmin. The difference in running economy meant that subject no:2 could run about 15 seconds faster per km at the same VO_2 level.

Running economy can be tested on treadmill or in the terrain. The treadmill running test gave, independent of sex, a similar level of explanation as VO_2max gave for running performance in the terrain (Fig 12).

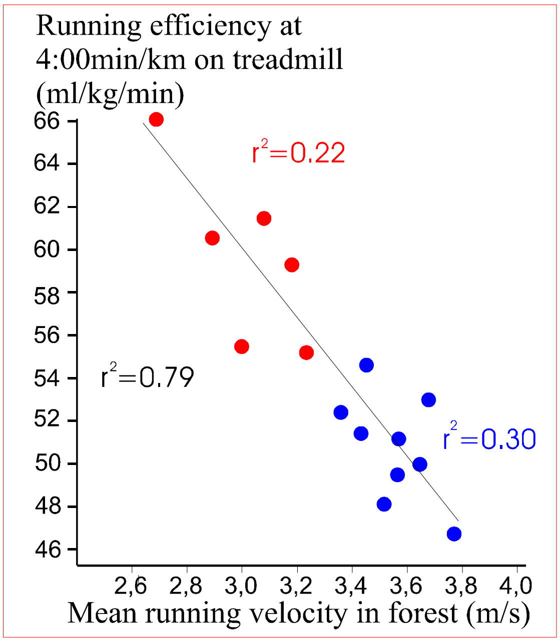

Fig 12. The relationship between running economy on treadmill at 4 min/km pace and average running speed during a simulated competition run on a marked terrain course for 15 runners.

An interesting secondary discovery was that the women tested appear to have poorer running economy than the men at 4 min/km pace (Fig 12). This difference seems to be due to the use of to high test speed rather than to a true gender difference because the 4 min/km testing pace resulted in an accumulation of lactate for the women, thus causing a higher oxygen consumption, which not was the case for the men.

In addition the relationship suggest that the fastest runners in terrain also showed the best developed running economy.
When recalculated as sec/km, treadmill running economy could only be used to predicted running performance with an error margin of ± 34 sec/km. Despite this being an improvement of ± 10 sek/km compared with the VO_2max test, it is still too imprecise to be used for intensity settings at elite level (Fig 13).

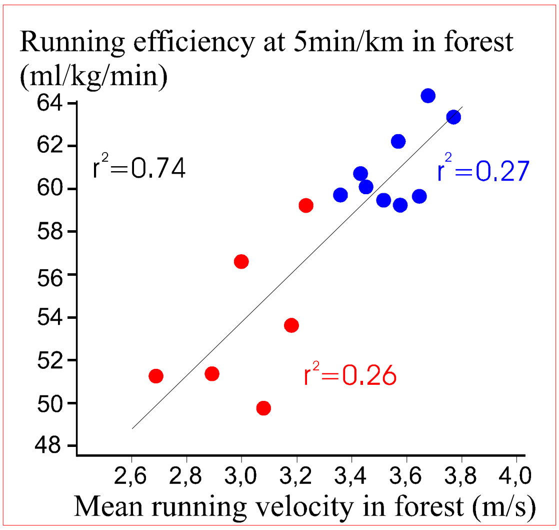

Fig 13. The relationship between running economy in terrain at 5 min/km pace and average running speed during a simulated competition run on a marked terrain course for 15 runners.

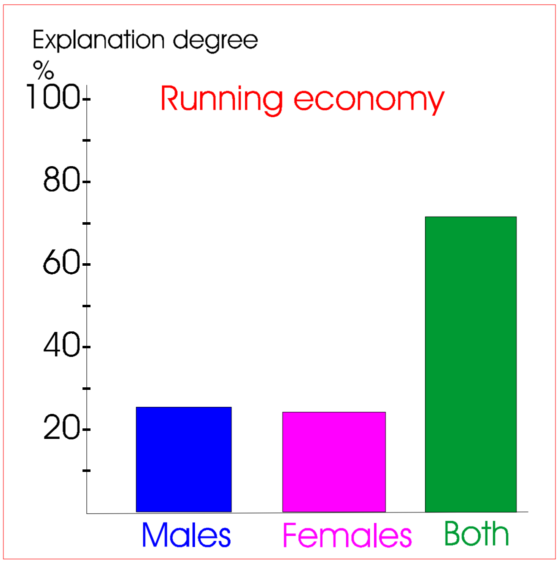

Fig 14. Description of the level of explanation that running economy in terrain gives for running performance during a simulated competition on a marked course in terrain.

However, in terrain a different pattern emerged. It appeared that the women tested had better running economy in the terrain than the men, in contrast to the results from the treadmill.

In addition it appears that the fastest runners in terrain also have the poorest running economy in terrain, contradicting the results from the treadmill. (Fig 13).

When recalculated in sec/km, the running economy test in terrain predicted running performance with a ± 30 sec/km error margin.

This result suggests that there is no correlation between running economy in terrain and treadmill running economy.

In addition the correlation is too weak to justify using running economy on its own to plan training, as about 75% of the differences in running performance cannot be explained by differences in running economy regardless of how running economy is measured (Fig 14).

When comparing treadmill running economy with running economy in terrain it was not possible to demonstrate any relationship at all (r^2=0.08) for the male runners, whilst a moderate relationship (r^2=0.77) existed for the women. (Fig 15).

Comparison of running economy in terrain and on the treadmill again indicates a gender difference.

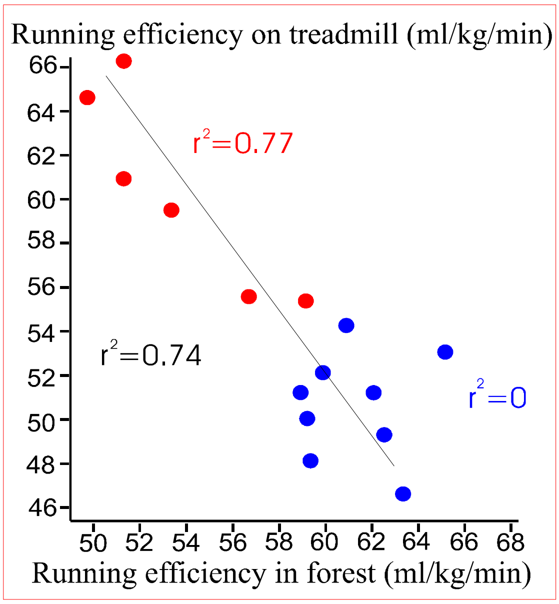

Fig 15. The relationship between running economy in terrain at 5 min/km pace and treadmill running economy at 4 min/km pace for 15 runners

While there is no correlation at all for the male runners, the values for female runners appear to show a correlation between good running economy in the terrain and poor running economy on the treadmill. The group is however too small to draw any definitive conclusions from.

From the training perspective these results show that running economy tests should be carried out in terrain and not on the treadmill as treadmill tests can lead to incorrect conclusions about good running economy, which is in reality poor in the terrain and vice versa.

If we instead investigate the relationship between VO_2max and treadmill running economy in combination, that is, the running speed reached at VO_2max (vVO_2max) and running performance the degree of explanation doubled from 20-25% to 40-45% (Fig 16).

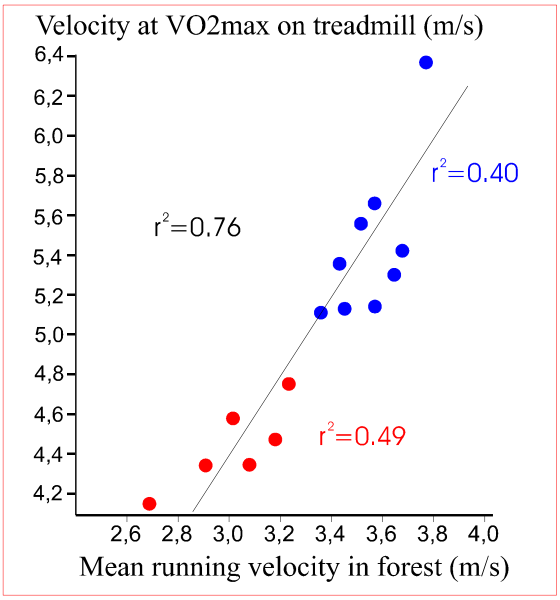

Fig 16. The relationship between treadmill running speed at VO_2max and average running speed during a simulated competition run on a marked course for 15 runners.

The increase in the degree of explanation meant that the margin of error for prediction was more than halved, from ± 30 sec/km to ± 13 sec/km. Despite this, the margin of error was still too large for the test to be used for intensity settings on elite level.

Finally, if the running economy value from the terrain test was used in combination with the VO_2max value the degree of explanation nearly doubled, from 40%-45%, to 74%-85%, and the error margin reduced to ± 9 sec/km (Fig 17 and 18).

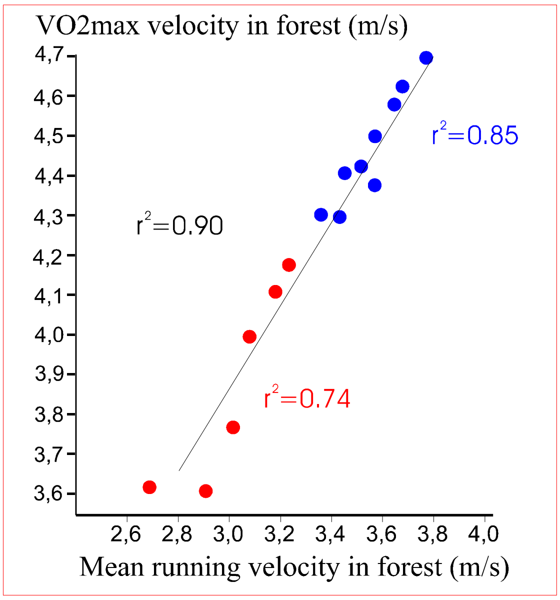

Fig 17. The relationship between running speed in the terrain at the VO_2max and average running speed during a simulated competition run on a marked course for 15 runners.

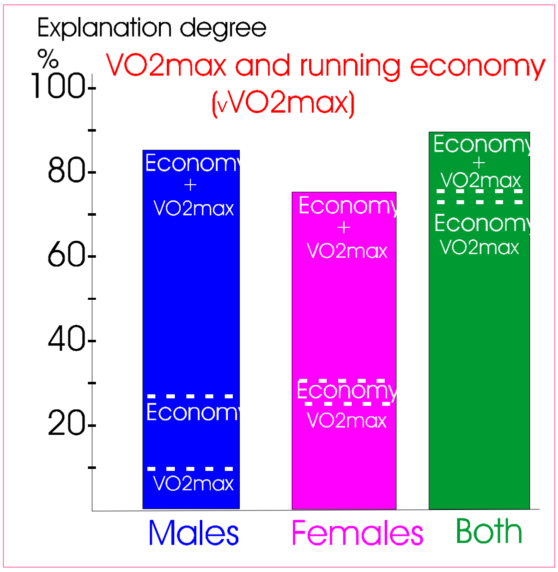

Fig 18. Description of the level of explanation that the velocity at VO2max in terrain gives for running performance during a simulated competition on a marked course in terrain.

An interesting and unexpected secondary discovery was the significant relationship between treadmill running economy and VO_2max (Fig 19 and 20).

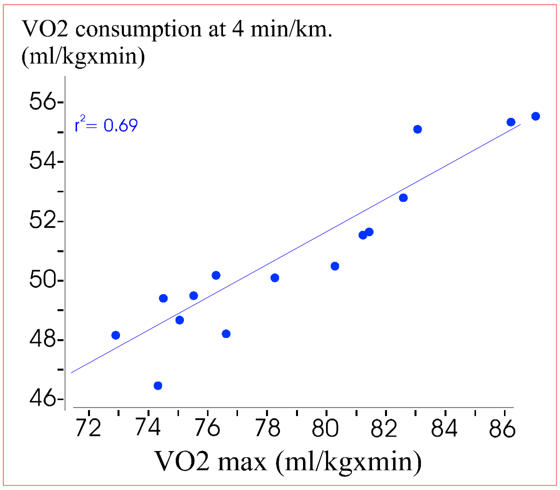

Fig 19. The relationship between treadmill running economy and VO_2max for 15 male seniors and juniors.

These comparisons are based on the runners who were tested at the camp in Portugal and also on runners who only were tested on treadmill in the laboratory.

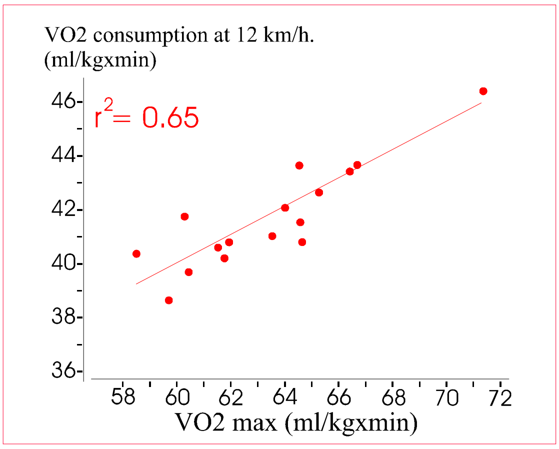

Fig 20. The relationship between treadmill running economy and VO_2max for 15 female seniors and juniors.

A further analysis of those runners who had taken part in camp in Portugal showed an even higher significant relationship between running economy in the forest and VO_2max compared with treadmill running.
The values for the men showed a degree of explanation as high as 90% for running economy as and explanation for differences in VO_2max (Fig 21).

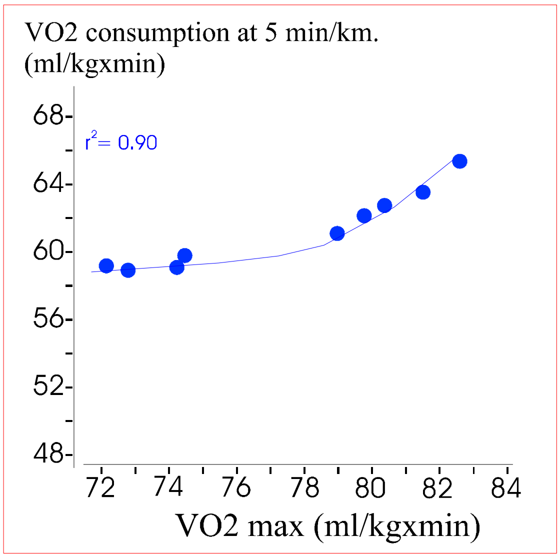

Fig 21. The relationship between running economy in terrain and VO2max for 9 male runners.

The corresponding figure for the women was 85% (Fig 22).

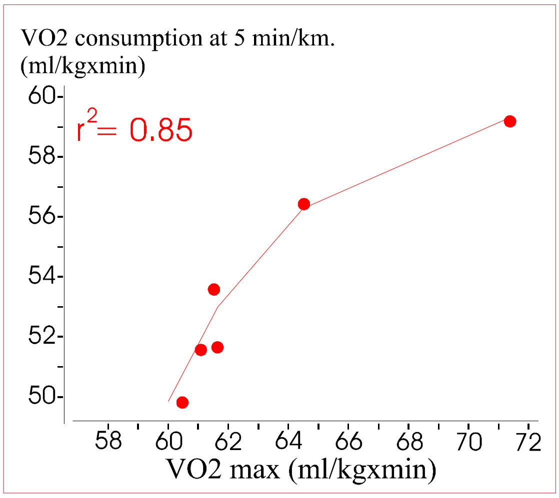

Fig 22. The relationship between running economy in terrain and VO2max for 6 female runners.

This relationship suggests that VO_2max does not only reflect central capacity and general fitness level. It also suggests that there is a strong connection between how efficient oxygen is used in the muscles and the adaptation of the heart to this level of effectiveness. This can in the worst case mean that the effect of a high VO_2max is cancelled and maximum running speed is the same, or even lower, compared with an athlete who has a low VO_2max in combination with a good running economy (Fig 23).

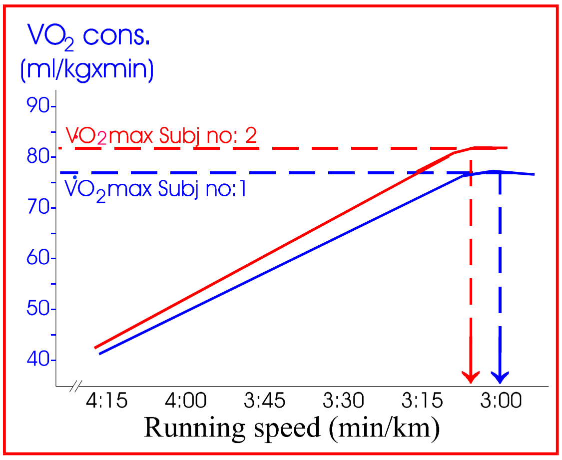

Fig 23. Differences in maximal running speed for two individuals with different VO₂max and different running economies. Individual 1 could run 6 sec faster per km compared with individual 2 because of his better running economy, despite the fact that individual 2 had a significantly higher VO₂max.

Further evidence for this is that if running economy is improved by specific running economy training then VO₂max might fall and stabilise at a level that meets the oxygen requirement at the new level of muscle effectiveness.

This has been demonstrated in three cases during one training year where the main aim of winter training has been to improve running economy. In these cases VO₂max reduced by an average of 1.8 ml/kgxmin during the year while running economy improved by about 3.2 ml/kgxmin at the same running speed (Fig 24).

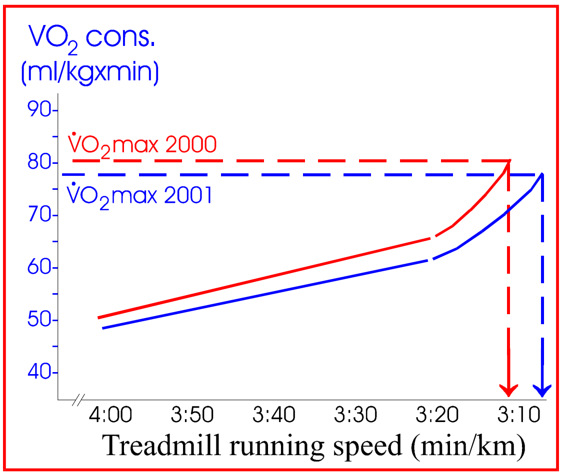

Fig 24. The average net effect of an improved running economy on treadmill on the theoretical VO₂max speed for two occasions – before and after one years running economy training for three runners.

The theoretical net effect of improved running economy with lower VO₂max was in the above case increased running speed during the treadmill test, with an average of 5 sec/km for the three runners.
In reality the average improvement was as much as 14 sec/km in terrain, as running economy in terrain improved by 6.6 ml/kgxmin at the same oxygen consumption level as the treadmill test (Fig 25).

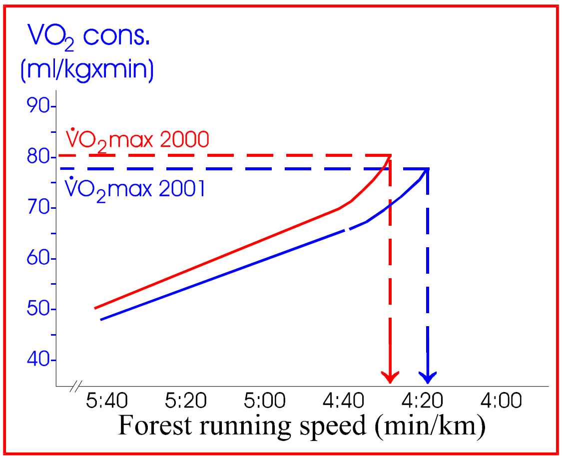

Fig 25. The average net effect of an improved running economy in the terrain on the theoretical VO₂max speed on two occasions – before and after one years running economy training for three runners.

The difference in improvement between the test on the treadmill and in the terrain again shows the importance of testing the individual in the right training and competition environment. Measurement of running economy must therefore take place in terrain and in combination with measurement of VO₂max in the lab to give a valid basis for evaluation of changes in both running economy and VO₂max. The validity for running economy in combination with VO₂max, with a method error ± 9 sec/km, is high enough to be a suitable method for evaluation of training. However, this error is still too large for the method to be used as a guide for training focus, volume and intensity. We have shown that muscle endurance gives further information as far as validity and carrying out training in practice is concerned. The last muscle capacity which we have measured during the project is covered in the following section.

3. Aerobic endurance: This describes the capacity of the muscles to work as near to VO_2max as possible for a period of at least 30 min, without relying substantially on anaerobic energy systems (4). The degree of endurance is limited by; l. fiber composition between slow (type 1) and fast (type 2a and 2b) twitch fibers, the greater the proportion of slow type 1 fibers the higher endurance capacity will be developed (4), 2. The development of the slow twitch fibers, which is dependent on their capillary density and mitochondria mass (5), 3. The energy effectiveness of the fat liberation which depresses the formation of lactate production (6), and, 4. The elimination of produced lactic acid out of the muscle (7) and the oxidation of produced lactate in heart and other muscle tissues (8).
If running speed is too high, certain muscle cells will form so much lactic acid that the pH falls. Lactate will be formed and is transported out of the cell to the surrounding tissue. When pH falls a reduction of the muscle contraction power and co-ordination occurs, and the individual will experience increasing tiredness. Eventually the individual must reduce running speed to a level where lactate production rate does not exceed the elimination capacity rate and instead reaches a maximal steady state level (MaxLass) at which the subject can work for at least 30 min (10). MaxLass is defined as the highest possible intensity which can be maintained during at least 30 min at the same time as blood lactate can be held at a steady state level (Fig 26).

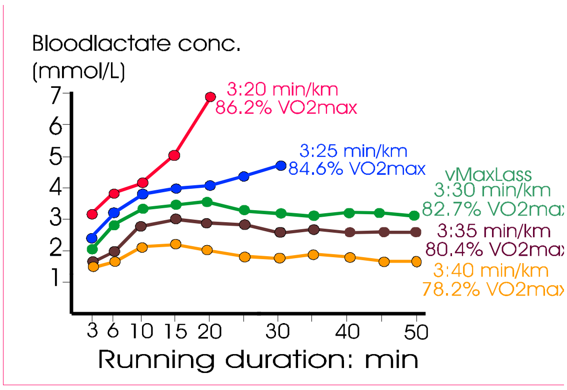

Fig 26. The difference in blood lactate concentration for five different test runs with different running speeds for one runner. Maximal lactate steady state pace was determined in this case to be 3:30 min/km which corresponded to a MaxLass intensity of 82.7% of VO_2max at a lactate concentration of 3 mmol/L.

The most accurate method for determination of MaxLass is for the individual to carry out 4-5 test runs each of 50 min on a treadmill at different steady speeds. The lactate concentration is measured at regular intervals and a steady state concentration is determined for different running speeds (Fig 26) (10). When a steady state concentration is no longer present the test is interrupted and the MaxLass can be determined (10).
However, this method, with five days of testing, is very expensive and impractical for the individual. A number of simplified prediction tests for MaxLass have been developed. One of the best known and most often used is the so called Onset of Blood Lactate Accumulation (OBLA) test. This test is also sometimes referred to as an Anaerobic Threshold test (AT). The test is carried out once with a steadily increasing running pace and based on an assumed level for lactate accumulation of 4.0 mmol/L regardless of the individual's level of training and muscle fiber composition (Fig 27).

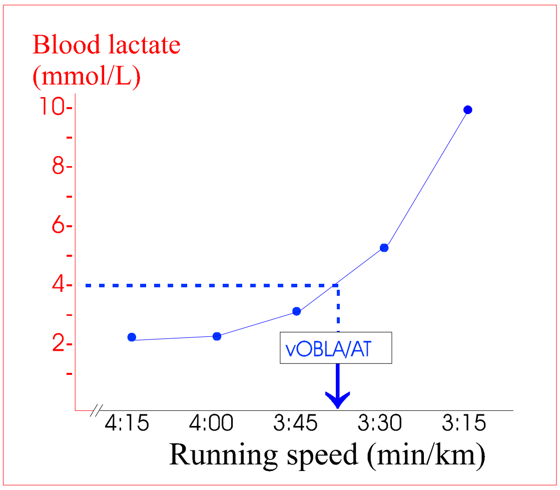

Fig 27. The effect of increased running speed on the blood lactate concentration for one runner during a OBLA or AT test on treadmill. The vOBLA/AT denotes tha critical running speed at an assumed concentration accumulation of 4.0 mmol/l.

These tests only give a reliable result at a so called group level (10). This means that only the average value for a group of individuals will be reliable, because of the large individual differences (2-7 mmol/L) in concentration from 4.0 mmol/L which can be observed (10).

The explanation degree for OBLA/AT for running performance was 67% for the men and 62% for the women, and the error margin increased to ± 14 sec/km which is worse compared to the VO_2max in combination with the running economy test. Therefore the OBLA test is not precise enough to be able to use for evaluation and planning of training at elite level (Fig 28).

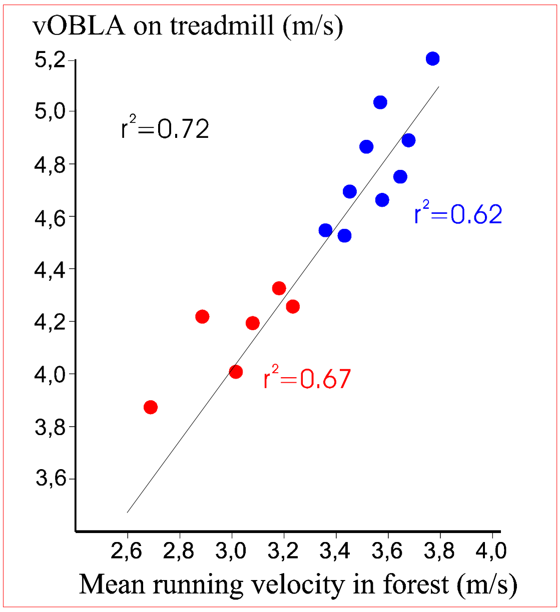

Fig 28. Relationship between treadmill running speed at OBLA and average running speed during a simulated competition run on a marked course for 15 runners.

The relationship that appears in our results is backed up by results from earlier publications covering endurance work for runners who have carried out several year's endurance training (12).

The treadmill lactate test in combination with an assumed MaxLass value of 4 mmol/L does not actually give better validity for predicting endurance capacity compared with running economy test in forest in combination with VO_2max.

A new treadmill test, the Fox-Lass test, was therefore developed. The definition of MaxLass in the new Fox-Lass test is; *the exercise intensity at which the lactate concentration is 0.7 mmol/L higher than the value after 4 min of exercise on the same intensity (fig 29).*

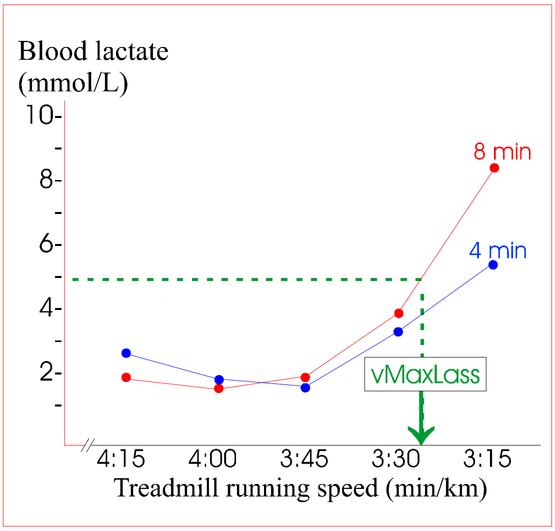

Fig 29. Differences in lactate concentration after 4 and 8 mins running at different running speeds for one runner during the new Fox-Lass test.

When the Fox-Lass intensity was used instead of the assumed OBLA value, the level of explanation for running performance increased from 62% to 87% for the men and from 67% to 92% for the women (fig 30).

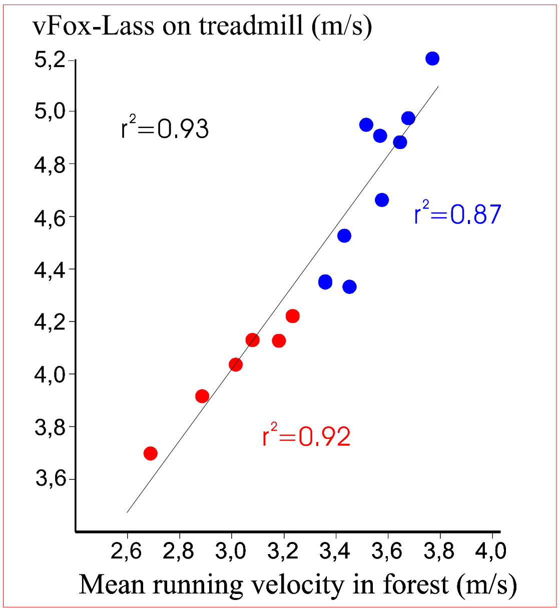

Fig 30. Relationship between treadmill MaxLass pace and average running speed during a simulated competition run on a marked course for 15 runners.

Moreover, the error margin fell from ± 9 sec/km to ± 6 sec/km which is sufficient to be able to use the test results for evaluation and planning of training because most runners can't set their training intensity in forest with higher precision in running speed than within 6 sec/km.

However, in its current form, the treadmill Fox-Lass test overestimated running speed by an average of approximately 1min/km for both groups. Currently athletes run on the flat at increasing speed, without any fixed or increasing gradient. This overestimation corresponded to a running speed of 3:50 min/km on MaxLass average for treadmill running, whereas testing in terrain showed the correct MaxLass speed to be 4:55 min/km.
Moreover, the relative endurance intensity level tested on treadmill (Fox-Lass%VO_2max) was underestimated by an average of 4%, 80.2% vs 84.2%, regardless of sex, compared with the correct average endurance level observed in the terrain test (Fig 31).

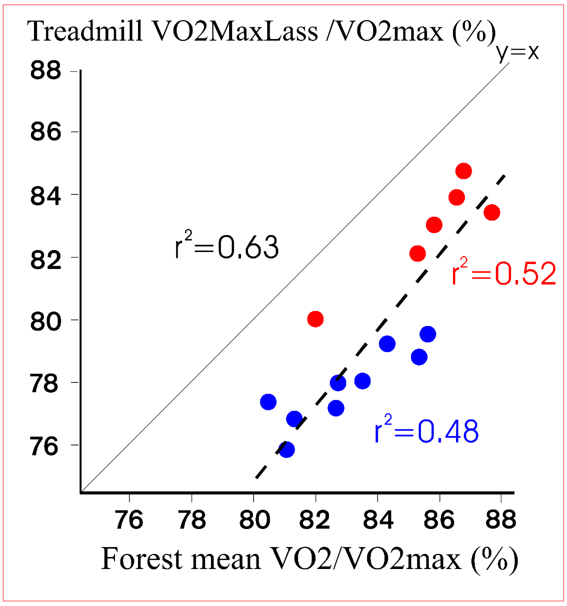

Fig 31. The relationship between relative Fox-Lass (%VO_2max) intensity on treadmill and mean relative intensity (%VO_2/VO_2max) during a simulated competition run on a marked course for 15 runners.

The difference in running speed for achievement of Fox-Lass on the treadmill, with very little vertical exercise, indicates a higher recruitment degree of fast type 2 muscle fibres compared to when running in terrain on the same level of VO_2 consumption. Such a recruitment will result in a higher production of lactate at a lower oxygen consumption level compared to when only type 1 muscle fibers are used for the exercise.

This theory can be demonstrated by a reduction in lactate concentration of 70% when using a slower running speed of 1 min/km in combination with an inclination angle of 3-4° when running on the treadmill compared to when running on a horizontal level for the same relative oxygen consumption level (Fig 32).

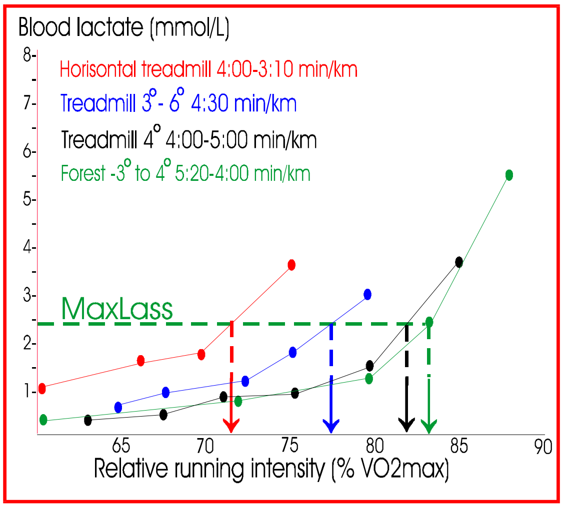

Fig 32. The difference in lactate response to different inclination protocols and to horizontal and forest running at the same relative level of VO_2 consumption for one runner on four different occasions.

A similar result was seen for two other cases which strongly indicates that future tests on the treadmill should be carried out with an inclination angle between 3-4° in combination with a 1 min/km slower running speed of compared to the running speed used for horizontal tests.
When comparing the average running speed during the forest test with the Fox-Lass predicted running speed during the same forest test (vFox-Lass) the degree of explanation for forest running capacity increased further from 87% to 90% for the men and from 92% to 94% for the women (Fig 33).
At the same time the margin of error was reduced from ± 6 sec/km to ± 4 sec/km on an individual level which is an equivalent precision to which the speed the runners can set their training intensity.

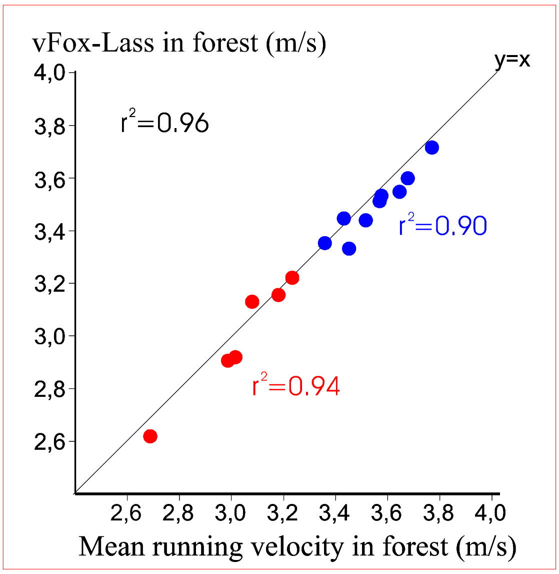

Fig 33. The relationship between forest Fox-lass velocity and average running speed during a simulated competition run on a marked course for 15 runners.

The high degree of explanation for the vFox-Lass speed on the running performance in forest, independent of sex, means that only about 6% of the variation in running performance between the runners is dependent of other variables that are unknown such as fatigue tolerance and motivation (Fig 34).

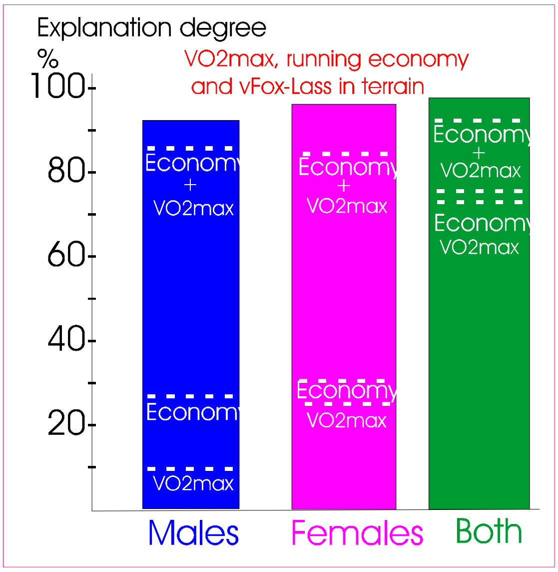

Fig 34. Description of the level of explanation that the velocity at Fox-Lass in terrain gives for running performance during a simulated competition on a marked course in terrain.

The highest validity of the investigated test methods was achieved when carrying out the forest test and is consequently recommended for testing athletes of an elite level. Especially if the aim of the test is to recommend training intensities the forest test gives more valid information about the local muscle efficiency and endurance capacity.

In the following section the Fox-Lass forest test and the perceived exertion of the runners during the test is described. The Fox-Lass test involves the runner completing 35-40 min of interval running wearing mobile analysis equipment (0.7kg) which can measure oxygen consumption, carbon dioxide production, and lung ventilation (Fig 35).

Fig 35. The portable oxygen analyser "Metamax 1" which allows measurement of oxygen consumption and carbon dioxide production in forest every 10:sec during 70-80 min.

Due to the big variation in vertical exercise during forest running the intensity can't be controlled or set by using a km speed. A more relevant way to set training intensity is to use a standardized rating scale of perceived exertion which has been developed earlier for sports testing (14) (Fig 36).

The Fox-Lass forest test consists of eight lap intervals, each of at least 900-1000m for the men and of 800-850m for the women, performed on a marked course. The two first laps are carried out at an RPE-level corresponding to the normal fatigue level during continuous/steady running. The next two laps are carried out at an RPE-level corresponding to the normal fatigue level during long interval (3-5 min) training.

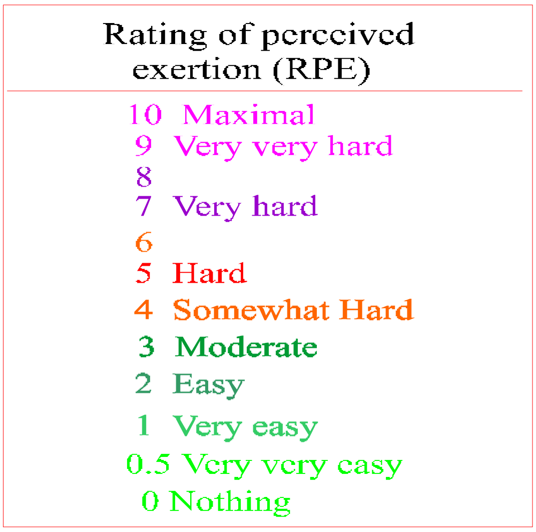

Fig 36. The rating scale of perceived exertion (RPE).

The next two laps are carried out at an RPE-level corresponding to the normal fatigue level during short interval (45-90sec) training. The last two laps are carried out at an RPE-level corresponding to the normal fatigue level during a 70 min competition for men and a 50 min competition for women.
After each lap the runner is stopped and a capillary blood sample from a finger tip is taken at the same time as the average RPE level is noted together with the elapsed running time.
After the test the collected values of oxygen consumption are analyzed and related to the relative intensity and to the earlier measured VO_2max (Fig 37).

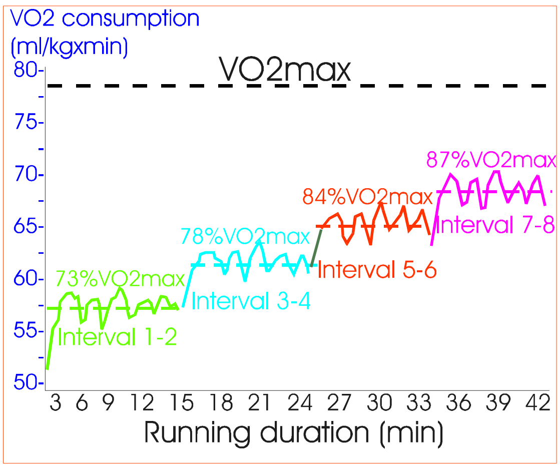

Fig 37. One example of oxygen consumption from a forest Fox-Lass test. The average value for each RPE level is denoted with striped lines and relative figures to VO_2max.

The lactate concentration for each interval is also related to the running speed (Fig 38) and to the RPE level (Fig 39).

The MaxLass intensity during forest running was assessed as either one of the three following definitions: 1) *the running intensity that corresponded to an increase in lactate concentration of at least 0.7 mmol/L between the two last interval levels in combination with a speed increase of no more than 3 sec/km (Fig 38).*

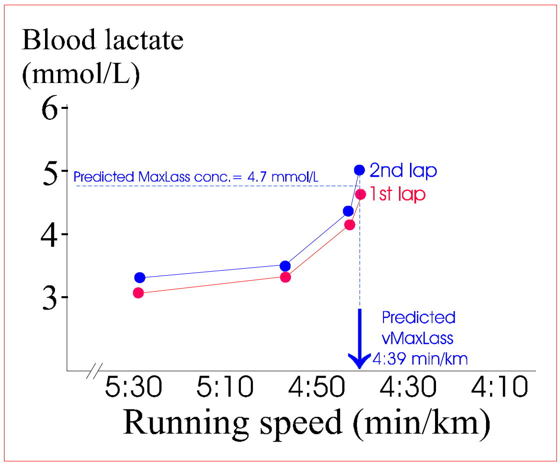

Fig 38. One repesentative example of the relationship between produced running speed and lactate response during the Fox-Lass test in forest for one runner.

2) *the intensity that resulted in a speed increase of no more than 3 sec/km between the two last interval levels despite an increase in RPE of at least 0.7 units (Fig 39).*

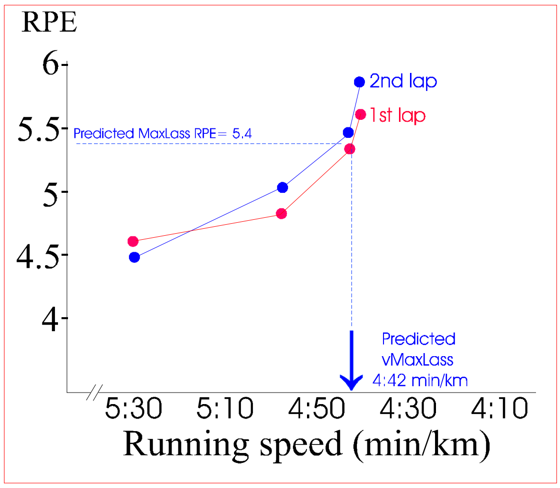

Fig 39. One example of the relationship between produced running speed and lactate response during the Fox-Lass test in forest for one runner.

3) *the running intensity that corresponded to an increase in lactate concentration of 0.7 mmol/L in combination with a speed decrease between the two last interval levels of no more than 3sec/km (Fig 40).*

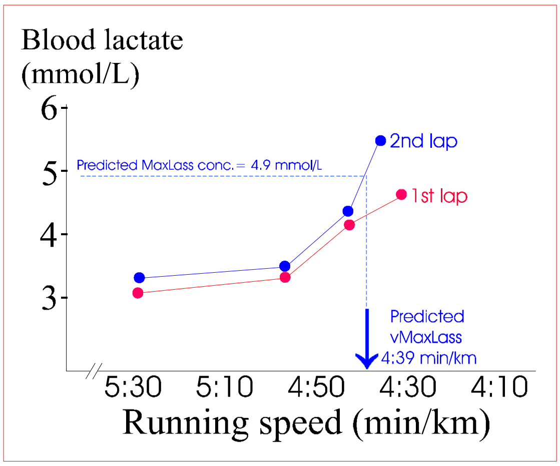

Fig 40. One example of the relationship between produced running speed and lactate response during the Fox-Lass test in forest for one runner.

If none of these definitions is fulfilled the MaxLass intensity can't be predicted and the test has to be repeated another day.
The use of three different definitions of the MaxLass during forest running is necessary because the individual variation in experience of setting running intensity in combination with the variation in relationship between the RPE and the lactate accumulation. These variations are not a problem when performing the test on a treadmill because the running speeds used are standardized and controlled.

The result from the forest test can be used in the following models:
1.a The test is carried out on the same terrain course which makes it possible to compare a change in running speed from time to time. In this case the effect of a training programme in terms of change in running performance speed and different aerobic capacities are possible to compare (Fig 41).

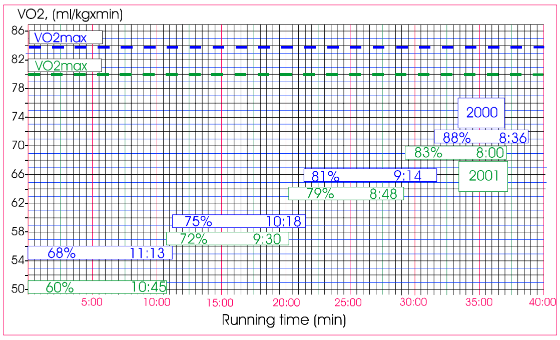

Fig 41. The difference in oxygen consumption and running speeds on the same terrain course for four different RPE levels before (blue color) and after (green color) one year of training on an optimized programme for one subject.

1.b A more interesting comparison for established senior athletes is the change in running economy that might occur when a change in VO2max no longer is possible (Fig 42).

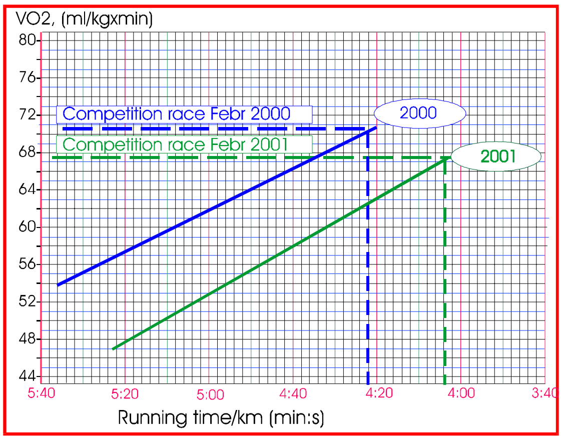

Fig 42. The difference in running economy on the same terrain course for four different RPE levels before (blue color) and after (green color) one year of training on an optimized programme for one subject.

1.c Moreover, it is also possible to detect a difference in lactate accumulation due to an increased endurance capacity in the muscles despite no change in VO_2max (Fig 43).

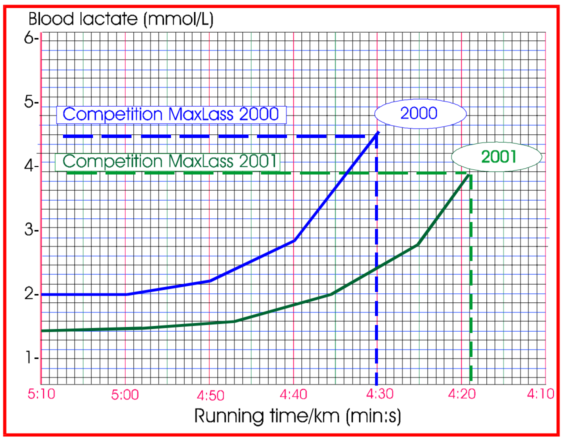

Fig 43. The difference in lactate accumulation on the same terrain course for four different RPE levels before (blue color) and after (green color) one year of training on an optimized programme for one subject.

The second way to use forest tests is when the test cannot be carried out on the same course. This can often be the case when competition preparations from a technical point of view has to be done in new terrain and the tests have to be carried out during the same week in that terrain. In these cases the running speed cannot be used due to different vertical work conditions.

Instead relative capacities have to be used as in the following models:
2.a The first model looks into a difference in relative oxygen consumption (Fig 44) which can reflect a higher endurance capacity or a higher fatigue tolerance. These two capacities are changed by different training models and are therefore important to investigate for the future training set up.

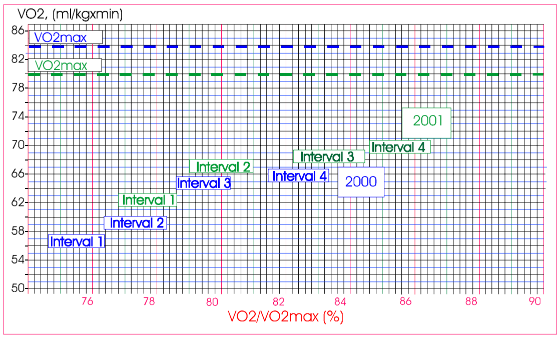

Fig 44. The difference in relative oxygen consumption on two different terrain courses for four different RPE levels before (blue color) and after (green color) one year of training on an optimized programme for one subject.

2b. The second model looks into the relative lactate accumulation response to the running performance in order to investigate if the lactate metabolism (muscle endurance) has changed (Fig 45).

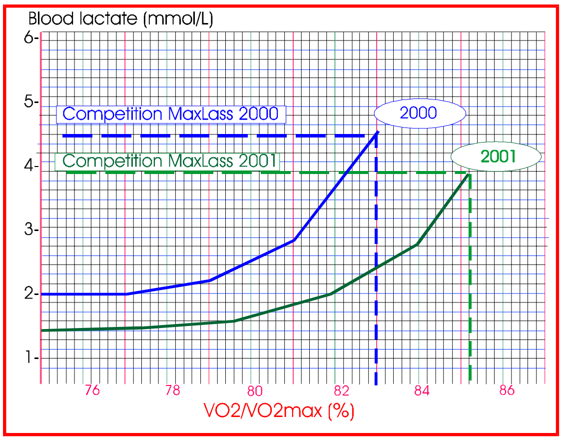

Fig 45. The difference in relative lactate accumulation and MaxLass on two different terrain courses for four different RPE levels before (blue color) and after (green color) one year of training on an optimized programme for one subject.

2c. The third model investigates the fatigue tolerance and the RPE figures are compared which can show an increased MaxLass RPE level which allows the athlete to run faster without an increased muscle endurance or running economy capacity (Fig 46).

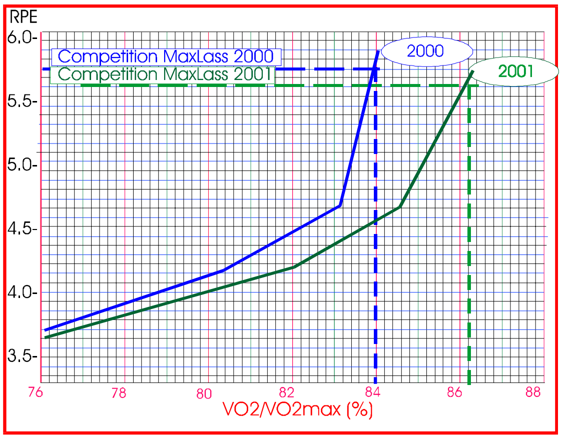

Fig 46. The difference in relative RPE level on two different terrain courses for four different RPE levels before (blue color) and after (green color) one year of training on an optimized programme for one subject.

These models allow a thorough and valid evaluation of the individual aerobic capacity independent of whether it has been tested in the lab or in the forest. In conclusion this chapter can be summarized as follows:

1. Aerobic performance during forest running can be explained to a degree between 90-94% by using the Maximal lactate steady state "MaxLass" concept. The "MaxLass" concept was used together with a new test protocol, the "Fox-Lass" protocol in combination with a new mobile oxygen analyzer, the "Metamax ll" and with measurement of finger capillary blood lactate.
2. The new "Fox-Lass" field test also allows a low method error for setting of optimal training intensities using a rating scale of perceived exertion, "RPE", at an individual level. An error of only ±4 sec/km between 6 and 4 min/km running speeds was found which probably will not have any significance on the oxygen consumed or lactate concentration.
3. If the "Fox-Lass" test for any reason cannot be carried out in the forest a similar test on the treadmill in the lab has been developed. However, the treadmill test was found to increase the method error from ±4 to ±6 sec/km which might cause unwanted effects for those athletes who are able to control their running speed with a higher precision.

4. The increase in method error was mainly due to the fact that running economy on the treadmill is not always a reliable predictor of running economy in forest. Athletes with poor economy in forest can have a good economy on treadmill giving false information to the coach and the athlete about the need for specific economy training.
5. Moreover, the endurance capacity in the forest was underestimated on treadmill by 4% mainly caused by high running speeds with no inclination when testing on the treadmill. Therefore an angle between 3-4^{o} is recommended with a decreased speed of 1 min/km compared to the speed used at horizontal level earlier.
6. The use of a rating scale for perceived exertion has been shown to be valuable in combination with oxygen and lactate measurements on different terrain courses. This is because running speeds from different courses cannot be used but the athletes rating figures can be used as a valid variable for increased aerobic capacity at submaximal level.

In the following chapter we will describe the training concept we have used and how the interpretation of the test results has been the base for an optimization training concept .

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