Power Diagnosis/Assessment in the Endurance Sports Maren Witt, Jürgen Küchler (1996)

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In the endurance sports primarily cyclical movements are decisive for competitive results. Biathlon is an exception because of shooting, likewise swimming because of the turns.

A further peculiarity appears in mass starts, where substantially heightened movement speeds are required at the beginning of the race. We find that in track running, cross-country skiing and more recently in triathlon.

While cyclical actions are demanded of athletes in the above named events, elevating speed at similar movement tasks places particular demands on energy sources. We will go into that further in a moment.

In the cyclically determined parts of endurance sport power endurance is an essential performance factor which in many sports is the limiting factor in performance. An improved power endurance expresses itself in an enlarging of the energy amount per movement cycle and with it the (forward) impulse performance over the competition distance at the same or elevated movement frequency. We proceed from the the point that fatigue which leads to a lessening of the energy per movement cycle has a strongly movement-specific character. This, for example, the medley swimmer Sievenen was able to achiece swimming speeds during his world record in 200m which equaled or even exceeded those of the best specialist in the Olympic final of 1996. This was particularly obvious in breast stroke in which the athlete needed very rapidly powerful muscle actions.

1. The Muscle Physiological Basis for Power Endurance

Power endurance is, like other power concepts, above all a characteristic of the neuromuscular system. It must be distinguished from endurance, which is a matter of cardio-pulmonary adaptation.

For power endurance performances energy is made available via the break down of glycogen. This results on the one hand in association with lactate accumulation via anaerobic paths and on the other hand through the complete break down via the citric acid cycle with the use of oxygen (aerobic metabolism path). The significance of the metabolic path is strictly dependent upon the loading time (division at approx. 2 minutes). Its intensification places very diverse demands on the biological substrate.

In most endurance sports the capacity of energy resource readying by way of using oxidative metabolism dominates, that is, the oxidative features of the muscle determine performance.

Adaptation phenomena in the muscle manifest themselves in it metabolic differentiation. For power endurance performances the development of the fast-twitch oxidative fibers is particularly important. Muscle fibers of this type can achieve high energy turn-over rates over a longer period of time. The operation of this fiber type is connected to middle to high stimulus intensities.

2. Power Endurance Diagnosis

The essential element of power diagnosis as well as power training is raising the resistance. This offer favorable preconditions for raising the energy amount per single movement cycle. Examples of possibilities of raising energy turn-over in the individual cycle are presented in table 1.

Table 1: Possibilities for enlarging the energy amount in an individual cycle in cyclical movements.

Methods	Explanation
Emphasize the single cycle in training	Alter the relationship of action- and pause-time, raising the inner-cyclical speed fluctuations
Raising the movement resistance	Brakes
Use of additional weights	Weight vests, foot or arm bands, heavy shoes or equipment for cyclical sport types (paddling, for example
Use of special training devices or ergometers	Basic elements of the movement are maintaned, significant resistance

In the various endurance sports a discipline-specific concept of power endurance performances has evolved. It is accomplished primarily with specific ergometers under near-competition conditions, since these ergometers provide the possibility to measure, which we cannot achieve in competition itself or only at great expense.

If the test takes place with heightened resistance, it ought to be only so large that the musculature can be evaluated in a functional relationship to competition. That means that a high correspondence ought to obtain in the intramuscular coordination and in the contribution of the participating muscles to the total task, because only in this way can it be assured that the specific work hypertrophy of the muscles will truly be what is responsible for the test result.

The proof of greater energy production is the individual cycle within the power endurance diagnosis is linked to various peripheral conditions. The prerequisite for determining rates of increase in power endurance performance is the achievement of equal or similar movement frequencies in retests. The frequency should in no case be higher than that in competitions.

Besides the movement frequency, the reactions of the heart-circulatory system need to be standardized. Within the course of the test the energy delivery in the single cycle also should not vary more than in the race. For most endurance disciplines that means only little energy output variances from the beginning of the test to the end be allowed, and that influences the energy output at the beginning of the test in relation to the absolute maximum.

In disciplines in which significant increase in energy is necessary at the beginning of the race (mass starts) this intensity should also be present at the beginning of the test.

We see an essential aim of the power endurance diagnosis in simulating the energy states of the working muscles in competition in order to gain information about the degree of marked improvement in the course of the training year independently of that being carried out in competition. For that reason it is recommended to get the maximal possibly energy delivery after establishing the movement pattern and the resistance to the movement. An endurance test ought to follow with a fixed beginning intensity. The length of the test is in accordance with the race distance/time.

3. Practical Application with Swimming the Example

In performance diagnosis of swimming the power endurance is tested with a semi-specific pulley device. First, the athletes carry out 10 maximal repetitions against a defined movement resistance. An endurance test follows in accordance with the race duration of 1,2, or 4 minutes with the

same movement resistance. The following parameters are set:

- -maximal work capacity in Newtons per meter (Nm)[Nm/sec=watts] per pull (as average of 10 repetitions)
- - total work in Nm in the endurance test
- - movement frequency, i.e number of pulls
- - average work in the individual cycle (as average of 10,20, or 40 sequential pulls in the entire course of the test
- - relative work capacity, and intensity (as a percentage of the average in comparison to the work capacity of the single pull)

Essential information can be derived for swimmers for their training level from the relative work capacity and intensity curve within the endurance test. A balanced level of power requisites is present, in our experience, when the intensities presented in table 2 are achieved by the athletes.

Table 2. Norm Values for the Intensity of an Individual Cycle

Test duration	pulls	intensity	pulls	intensity	average value
1 minute	1st 10 pulls	>95%	last 10 pulls	>85%	90%
2 minutes	1st 20 pulls	90%	last 20 pulls	>80%	85%
4 minutes	1st 40 pulls	80%	last 40 pulls	80%	80%

The maximal work capacity of an athlete depends in high degree from his anthropometric pre-conditions (body size, arm length, etc.). A performance capacity is present only if the structure of the endurance test allows us to expect and further improvement over the rise in the standard of comparison.

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A high correspondence has been shown between the test results in the laboratory and the results in the water.

4. Consequences for Training

In investigations which accompany training, metabolic reaction to various loading stimuli were studied. It was established that in a power endurance series of 1 minute durations (table 3) very high cumulative lactate values appeared. The intensity of the work in a single cycle was comparatively low, however.

Table 3. Lactate concentration and intensity in a single cycle on a power training device with a series duration of 1 minute.

lactate	Mmol/l	4x60sec/2-3 min. rest				
Sa	10 pulls	1. series	2. series	3.series	4. series	intensity
S	3.4	4.9	5.9	5.6	7.1	72.00%
S	3.5	5.3	7.6	9.5	8.6	79.00%
F	4.5	7	10.5	12.4	12.4	84.00%

Table 4 makes the possibilities clear which are yielded from the interval method. The fewer the number of repetitions within a series, the lower the lactate concentration in the blood. At the same time the intensity of the single cycle can be significantly elevated. In this way a highly intensive power endurance training in the aerobic-anaerobic transition zone becomes possible.

Table 4.

series	6x10 repetitions		4x20 repetitions		1x40 repetitions	
	butterfly	freestyle	butterfly	freestyle	butterfly	freestyle
Lactate mmol/l	3.62	3.37	4.34	4.20	4.49	4.29
Intensity (%)	91	83	89	78	86	68
Heartrate (min-1)	142	133	135	139	151	161

Summing up one can say that the aim of the power endurance training consists of raising the energy delivery in the individual cycle while assuring a high total repetitions number and while primarily utilizing aerobic or aerobic-anaerobic [transition zone] metabolism. A high intensity turn-over/impulse performance in the individual cycle (demand on FT fiber type) is thus guaranteed. A systematic alternating in carrying our the movements (alternating, synchronous arms strokes) can contribute to lessening the movement-specific fatigue. The intensive interval method is [thus] suited to this conversion method.

Main principles: RT's synopsis

1. Maintain race-specific speed of movement.

-resistance is high but not too high, and remains constant

-force is thus produced volitionally through speed of activation rather than response to highest resistance.

-allows enough total cycles (repetitions) to embed the desired stimulus

2. Stay in aerobic – aerobic/anaerobic zone. This is the threshold or transition zone, i.e. threshold + 2-3 bpm over, not more. If that specific zone is exceeded, the stimulus becomes non-specific for power endurance. That is the message of the 4x1 minute protocol, Table 3, in which the lactate levels accumulate too severely, even while intensities (power output per cycle) remain relatively low.