

ENERGY ZONES IN SWIMMING

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Why Are Energy Zones Important For Swimmers?

The importance of energy zones in swimming is based on the existence of several different pathways to recycle energy in the muscle cells during exercise. The main pathways of energy recycling are non-aerobic metabolism (creatine phosphate), anaerobic metabolism (anaerobic glycolysis), and aerobic metabolism. Metabolism is the process of storing and releasing the energy. Energy for the body is stored in different forms and pathways are used to convert these forms into accessible energy that an athlete can use to perform work. There are no “borders” to energy pathways in a body. At any given time, several pathways, not just one, may be engaged in energy production but dominance of an energy source depends on the duration and intensity of the exercise. Usually workload is broken into several energy “zones” based on the duration and intensity of the training. Energy “zones” allow athletes and coaches to develop a specific pathway of energy recycling and to quantify, track, and plan the physiological adaptations desired for their specific event.

There are several reasons for understanding energy zones in swimming:

1. Swimming sets of different duration and intensity are supported by energy from different sources. During high intensity short-term swimming bouts most energy is recycled through the anaerobic pathway. It is a fast and non-oxidative way for energy recycling. During low intensity long-term swimming bouts the energy is recycled mostly aerobically using oxygen. This way is slow but more efficient than the anaerobic way.
2. Improvement of one energy system does not influence another one. When athletes swim long distances they develop mostly aerobic energy sources. High intensity swimming develops the anaerobic energy sources. Different swimming events require the training of different energy pathways.
3. The same swimming set can be swum in different energy zones. For example, swimmers can swim sets with higher or lower intensities. This will recruit different pathways of energy recycling.
4. The preparation of competitive swimmers requires evaluation of individual swimming intensities in each energy zone. The same swimming intensity or even heart rate affects the energy recycling pathways differently when athletes are at different stages of the season (i.e., detrained or at peak performances). Adaptation in athletes to the same swimming intensity depends on their current condition, types of muscle fibers, training history, and other factors. Therefore it is important to test athletes during a season and select appropriate swimming intensities (heart rate) to train different energy zones.

Energy Forms In The Body

Adenosine Triphosphate (ATP) is the only source of potential chemical energy in the body. It consists of one molecule of protein (adenosine) and three molecules of phosphate. Muscle cells always contain free ATP, which reduces to ADP (adenosine diphosphate) and releases the energy during the first few seconds of work (figure 1).

Decomposition of ATP into ADP releases the energy and phosphoric acid, which increases the acid environment in the muscles. Then other energy storage forms are used to recycle ADP back to ATP through different pathways.

Energy forms in the body include:

- Adenosine Triphosphate (ATP)
- Creatine Phosphate (CP)
- Glycogen (glucose)
- Fats
- Proteins

Working capacity in athletes depends more on the rate of recycling ATP (from CP, glycogen, fats and proteins) than on the amount of ATP. With training, ATP-CP increases less than 20%, while working capacity (swimming velocity) increases more dramatically.

Pathways of Energy Metabolism

There are three main pathways of energy metabolism:

1. Creatine Phosphate (immediate non-oxidative way of energy recycling)
2. Anaerobic Metabolism (anaerobic-glycolytic non-oxidative way of energy recycling)
3. Aerobic Metabolism (oxidative way of energy recycling)

Metabolism of Creatine Phosphate is the process of recycling ATP from CP. CP is stored in muscle cells. It very rapidly recycles ATP from ADP. Usually after 2-3 seconds of high intensity work, free ATP stores in muscle cells are depleted. Then CP phosphate is involved to recycle ATP. After 10-15 seconds of high intensity work the rate of recycling ATP from CP is slowed down. Creatine Phosphate has very high power, low capacity, and low efficiency.

Examples of swimming sets and distances to develop creatine phosphate metabolism: diving and turns, short distances (10-25 M/Y) with maximum intensity, swimming sets with short distance and long rest interval (i.e., 4-6 x 12.5 M/Y, 2-4 x 25 M/Y with rest interval 1-3 min.).

Anaerobic Metabolism (Anaerobic-Glycolytic) is the non-oxidative process of recycling of ATP from glycogen. Glycogen is stored in the muscle cells. Glycogen fairly rapidly recycles ATP, but it is slower than from CP. Anaerobic metabolism produces lactate. It is the main energy system for exercise bouts of 30 sec until 3 min. When distances are longer, aerobic metabolism predominates. Anaerobic metabolism has high power, middle capacity, and low efficiency.

Examples of swimming sets and distances that develop anaerobic metabolism: distances of 50 to 300 M/Y, high intensity swimming sets with short rest interval (i.e., 6-16 x 25 M/Y, 4-8 x 50 M/Y, 2-4 x 100 M/Y, 2 x 200 M/Y with rest interval 20-30 sec etc.).

Aerobic Metabolism is the oxidative process of recycling ATP primarily from glycogen. It is a slow process of recycling ATP. Glycogen for aerobic metabolism is stored in muscle, liver, and blood. Fats and proteins can be involved in aerobic metabolism also, but this process is very slow (long distance swimming).

Aerobic metabolism is the main energy system for distances longer than 4 min. The longer distance, the more energy derived from aerobic metabolism. Aerobic metabolism takes place in a small intracellular organelle called mitochondria. Aerobic metabolism has low power, high capacity, and high efficiency.

Examples of swimming sets and distances that develop aerobic metabolism: distances of 2000 M/Y and longer, low and middle intensity swimming sets with short rest interval (i.e., 20 and more x 100 M/Y, 10 and more x 200 M/Y, 7 and more x 300 M/Y, 5 and more x 400 M/Y etc.).

Energy Zones (Categories) In Swimming

Based on the physiological responses of athletes to different intensities, workload volume can be divided into the several energy zones in swimming. There are several classifications of workload. Characteristics of energy zones are presented on Table 1.

Table 1

CHARACTERISTICS OF ENERGY ZONES

7 Energy Zone System	Total Set Duration (m)	Total Set Duration (min)	HR (bpm)	HR (% max)	Work:Rest ratios	Sample Set (*for a Sr. Age Group swimmer)
AEROBIC (RECOVERY)	Variable	Variable	< 140	< 70	N/A	600 Easy Swim
AEROBIC DEVELOPMENT (EN1)	1500 - 4000	≥ 15	140 - 160	70 - 80	10 - 30 sec rest	6-10 x 400 Swim/ 10 sec rest
AEROBIC/ANAEROBIC MIX 1 (EN2)	800 - 2000	10 - 40	160 - 180	80 - 90	15 - 30 sec rest	4-6 x 300 Swim 15 sec rest
AEROBIC/ANAEROBIC MIX 2 (EN3)	600 - 1600	8 - 30	180 - Max	90 - 100	30 - 60 sec rest	4-8 x 150 Swim/ 30 sec rest
ANAEROBIC 1 (SP1)	200 - 600	2 - 15	Max	100	2:1 - 1:1	2-3 sets of 6-8x50 race tempo/ 10-30 sec rest or 4 x 125 Rotate IM/ 45 sec rest
ANAEROBIC 2 (SP2)	200 - 600	4 - 12	Max	100	1:2 - 1:4	4 x 75 Swim/ 3-4 min rest or 6 x 50/ 2 min rest
SPRINT (SP3)	25 - 100	1 - 2	Max	100	1:3 - 1:4	4-6 x dive 15m/ 1 min rest or 6-8 x 12.5 Swim/ 45 sec rest

Europeans are using the five zone classification based on sources of energy recycling: zone 1 – aerobic recovery, zone 2 – aerobic development, zone 3 – mix aerobic anaerobic, zone 4 – anaerobic, and zone 5 – creatine phosphate.

Since both zones 1 and 2 are aerobic, often these zones are combined. In this case there are four energy zones (aerobic, mix, anaerobic, and creatine phosphate). Swimming sets in these zones depends on the rest interval and intensity. Classifications for four energy zones with 15 to 20 seconds rest interval are presented in Tables 2 and 3. If rest interval is longer (30 to 40 sec), swimmers can maintain higher intensity longer time at the same energy zone (table 3).

Table 2

EXAMPLES OF TRAINING SETS IN ENERGY ZONES
WITH ALL-OUT EFFORTS

15-20 SEC REST INTERVAL

Pace of set M or Y	SP3 (Zone 5)	SP1-2 (Zone 4)	EN2-3 (Zone 3)	EN1 & REC (Zone 1-2)
Number of repetitions				
25	1-3	4-16	18-60	62 & more
50	1	2-7	8-26	27 & more
75		1-4	5-16	17 & more
100		1-3	4-12	13 & more
150		1-2	3-8	9 & more
200		1	2-6	7 & more
400			1-3	4 & more

Table 3

EXAMPLES OF TRAINING SETS IN ENERGY ZONES
WITH ALL-OUT EFFORTS

30-40 SEC REST INTERVAL

Pace of set M or Y	SP3 (Zone 5)	SP1-2 (Zone 4)	EN2-3 (Zone 3)	EN1 & REC (Zone 1-2)
Number of repetitions				
25	1-5	6-20	22-70	72 & more

50	1	2-9	10-32	33 & more
75		1-6	8-21	22 & more
100		1-4	5-15	16 & more
150		1-3	4-10	11 & more
200		1-2	3-7	8 & more
400			1-4	5 & more

From these tables coaches can select any swimming set in all energy zones. For example, if athletes need to swim 300 m or yards in anaerobic energy zones (SP1-2 or Zone 4), coach can select swimming sets according to Table 2 and 3: 12 x 25 :15-30 sec rest, 6 x 50 :15-30 sec rest, 4 x 75 :15-30 sec rest and so on.

USA Swimming uses 7 energy zones (categories): recovery, endurance 1, endurance 2, endurance 3, sprint 1, sprint 2, and sprint 3. Characteristics of the seven energy categories are presented in Table 1.

All energy zones are based on the duration of exercise. When athletes swim sets with longer duration, the relative intensity of sets is lower. Therefore, athletes use a lower energy zone. Some swimming sets are designed for technical improvement. For example, athletes are doing drills or skill exercises in water. These skill exercises can be done with various efforts (50%, 90%, or 100%). Swimmers can't swim the same distance with skill exercises as they swim with full body stroke. In this case the time spent doing skill exercises can be converted to the expected distance athletes should swim. Below are presented two tables for skill exercises for age group (Table 4) and senior swimmers (Table 5). Senior swimmers can swim longer distance with the same relative intensity then age group swimmers. For example, if an age group swimmer is doing skill exercises for 1 min with 100% (maximum) relative intensity, this time can be converted to the 75 m distance in energy zone SP2 (anaerobic or Zone 4). There are no included conversions to the SP3 (creatine phosphate, sprint, or Zone 5) energy zone. This is because duration of SP3 is very short, up to 15-20 seconds. Skill exercises and drills are very rarely swum in the SP3 energy zone.

Table 4

**CONVERSION FOR SKILL EXERCISES "TIME – DISTANCE"
AGE GROUP SWIMMERS**

Time, Min	Distance with different efforts, meters					
	SP2 100%	SP1 90%	EN3 80%	EN2 70%	EN1 60%	REC 50%
1	75	70	60	55	45	40
2	150	125	125	100	100	75
3	225	200	175	150	125	125
4	275	275	225	200	175	150
5	350	325	300	275	225	200
6	425	400	350	325	275	250
7	500	450	400	375	325	275

8	550	525	450	425	350	325
9	625	575	525	475	400	350
10	700	650	575	525	450	400

Table 5

**CONVERSION FOR SKILL EXERCISES “TIME – DISTANCE”
SENIOR SWIMMERS**

Time, Min	Distance with different efforts, meters					
	SP2 100%	SP1 90%	EN3 80%	EN2 70%	EN1 60%	REC 50%
1	100	90	80	70	60	50
2	175	175	150	125	125	100
3	275	250	225	200	175	150
4	350	325	275	250	225	200
5	425	400	350	325	275	250
6	525	475	425	375	325	275
7	600	550	500	450	375	325
8	675	625	550	500	450	375
9	775	700	625	550	500	425
10	850	775	700	625	550	475

Conclusions About Energy Zones

All energy zones are relative. There are no borders between energy zones, however each zone has a primary pathway for energy recycling. Understanding energy zones is helpful in classifying swimming sets and developing particular pathways for energy recycling. Coach use different classifications of energy zones. Scientists can define many energy zones, but the coach should decide himself or herself on the number of zones. The more energy zones, the harder it is to define borders between them. Therefore, if a coach would like to use more energy zones, he/she should know exactly what swimming sets belong to different energy zones. This would be helpful to track the workload more precisely.