Exercise Physiology
Dr T Noakes

(This paper was presented at the recent SYMPOSIUM 78 of BAROLOGIA, the South African Society for Underwater Science, to whom our thanks are due for permission to reprint.)

Exercise may be classified as either static or dynamic. During static exercise, like weight-lifting, the active muscles remain contracted for the duration of the activity, whereas during dynamic exercise, typified by running, the active muscles contract and relax repetitively. The fundamental physiological difference between the two exercise types is that during static exercise skeletal muscle blood flow is reduced or stops completely. Thus the muscle cell is isolated from the cardiovascular system and must work under conditions of ischaemia (reduced or absent blood flow). In the absence of oxygen, cellular energy requirements must be met by the anaerobic metabolism of glycogen. In contrast, during dynamic exercise muscle relaxation allows the flow of oxygen and nutrients to the muscle cell. Thus the energy requirements of dynamic exercise can be met by oxidative metabolism in skeletal muscle mitochondria, to which the metabolism of blood-borne free fatty acids and glucose can contribute.

As the two different exercise types stress different metabolic pathways, it is reasonable to expect different cellular adaptations to training with either exercise type. Dynamic exercise, because it stresses oxidative metabolism, induces adaptation in skeletal muscle mitochondria (the site where oxidative metabolism occurs). There is an increase in the number, size and enzyme content of these mitochondria. The result is that dynamically trained skeletal muscle has an enhanced capacity to generate oxidative adenosine triphosphate (ATP), particularly from free fatty acids. The effect is that during exercise the trained person produces a greater percentage of his energy from fatty acid rather than carbohydrate metabolism. As the total body carbohydrate stores are limited, and since fatigue during prolonged exercise coincides with body carbohydrate depletion, this enhanced capacity for fat in place of carbohydrate metabolism explains, in part, the superior endurance capacity of the trained person.

For reasons that are not yet clear, the cardiovascular adaptations to training (ie. the reduction in heart rate, blood pressure, and in skeletal muscle blood flow during submaximal exercise) are limited to exercise with the trained muscles. This suggests that they depend on a peripherally situated training adaptation rather than on intrinsic adaptation in the heart itself. Current evidence suggests that this is due to a training induced resetting of the synpathitic nervous system, so that the sympathetic activation during exercise is reduced by training. It has been speculated that a link exists between increased skeletal muscular oxidative capacity and reduced sympathetic activity.

Training with static exercise does not produce a change in skeletal muscle mitochondrial function. There is skeletal muscle hypertrophy through an increase in contractile proteins and this is manifest as a change in strength. No change in overall cardiovascular function occurs in persons who train exclusively with static exercises.

In summary, adaptations to physical training are absolutely specific to both the type of exercise and to the specific muscle groups used in training. Thus the best training programme for a particular sporting activity is the activity itself, provided that the activity is sufficiently strenuous to produce a training effect. Swimming therefore more closely covers the needs of the underwater diver than does running, because the latter (1) fails to train the arms, and (2) trains the hamstring muscles at the expense of the quadriceps (which are more active in swimming); or weight lifting, because it is a static exercise.

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North Queensland Diving Medicine Conference
Hinchinbrook Island

* This conference was held 28 August to 3 September 1978. Ten persons attended plus a diving instructor. Despite a run of bad luck, inclement weather, boats breaking down, etc, the North Queensland branch of SPUMS was established. The clinical sessions included lectures by Dr John Rubinson and Dr Dennis Pashen, based mainly on case histories, followed by general discussion on a wide range of topics. These included Round Window injuries, Sinus Barotrauma, Hyperventilation, Drowning, Coral injuries, and "jelly" stings.

* The SPUMS meeting was held on Saturday night and Dr Pashen was asked to continue as the acting Regional Director. It was decided to hold an in-service weekend and long weekend training sessions with guest speakers from both the north and from other states. A ten day trip to the Ribbon Reefs was organised for November (and fully filled).

* Notification of the next Regional branch meeting will be sent out to the individual members. Persons wishing to be placed on the mailing list should contact Dr Dennis Pashen, 3 White Street, Ingham Queensland 4850.

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SEA SECRETS
(March-April 1978)

QUESTION: What is the difference in metabolism and respiration that allow a lobster to stay alive for days out of the water, while a fish would die if subjected to this condition?

SV, Willimantic, Connecticut

ANSWER: Cold-blooded animals (poikilotherms) are fairly similar in their metabolic rates. Differences relate to differences in activity; eg. an active fish (tuna) would have a greater metabolic rate than the lobster which, in turn, would have a greater metabolic rate than an inactive fish (eg. toadfish).

The answer lies in the nature of the gills. For most fishes, these are very fine structures which collapse when the fish is taken out of water. They can no longer take up oxygen, and the fish dies of asphyxiation. Lobsters have coarser gills, and they can also take up oxygen from the branchial chamber. In a 100 percent humid environment, some respiration is possible, sufficient to enable the lobster to survive several days. Fishes that can take up oxygen by routes other than the gills can also survive several days in air: eg. eels and catfishes use their skin to supplement respiration. These fishes can survive several days in air if kept cool and kept in 100 percent humid conditions (eg. wrapped in wet newspaper).