RECOVERY

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- **Post exercise recovery** is one of the fundamental principles of exercise training.
- Intense exercise often leads to fatigue, increased body temperature, dehydration, depletion of muscle glycogen and soft tissue damage.
- The general goals for postexercise recovery are to restore homeostasis, replace fuels and fluids, repair the body's tissues, and rest.

OXYGEN UPTAKE DURING RECOVERY: "OXYGEN DEBT"

Bodily processes do not immediately return to resting levels after exercise.

In **light exercise**, recovery to a resting condition takes place rapidly and often progresses unnoticed.

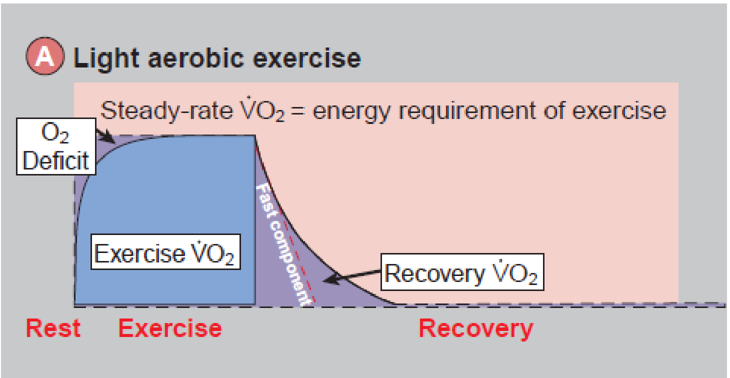
Intense physical activity requires considerable time for the body to return to resting levels. The difference in recovery from light and strenuous exercise relates largely to the specific metabolic and physiologic processes in each exercise mode.

British Nobel physiologist A.V. Hill (1886–1977), referred to oxygen uptake during recovery as the **oxygen debt.**

Instead, **recovery oxygen uptake** or **excess post-exercise oxygen consumption** (**EPOC**) now defines the excess oxygen uptake above the resting level in recovery. This specifically refers to the total oxygen consumed after exercise in excess of a pre-exercise baseline level.

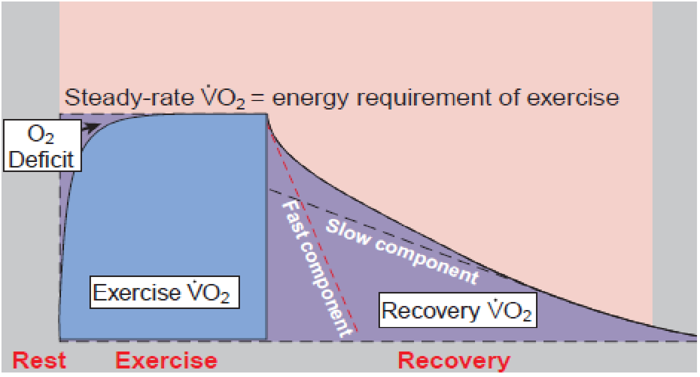
During Light Aerobic Exercise

Light aerobic exercise (Panel A), rapidly attains steady-rate with a small oxygen deficit. Rapid recovery ensues from such exercise with accompanying small EPOC.



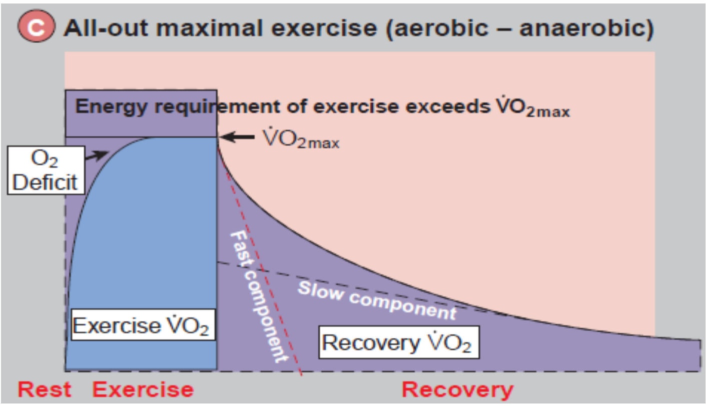
During Moderate to Intense Exercise

In Moderate to intense aerobic exercise (Panel B), it takes longer to achieve steady rate, so the oxygen deficit increases compare with light exercise.
Oxygen uptake in recovery from relatively strenuous aerobic exercise returns more slowly to pre-exercise resting levels. Recovery oxygen uptake initially declines rapidly (similar to recovery from light exercise) followed by a gradual decline to baseline.



In both Panels A and B, computation of the oxygen deficit and EPOC uses the steady-rate oxygen uptake to represent the exercise oxygen (energy) requirement.

During Exhausting Exercise (Non steady rate)
During exhausting exercise, illustrated in Panel C, a steady rate of aerobic metabolism cannot be attained.
This produces a large accumulation of blood lactate; it takes oxygen uptake considerable time to return to the pre-exercise level.
It is nearly impossible to determine the true oxygen deficit in such exercise without establishing a steady rate; in this instance the energy requirement exceeds the individual's maximal oxygen uptake.



No matter how intense the exercise (walking, bowling, golf, snowboarding, wrestling, cross-country skiing, or sprint running), an oxygen uptake in excess of the resting value always exists when exercise stops. The *shaded area* under the recovery curves indicates this quantity of oxygen; it equals the total oxygen consumed in recovery until attaining the baseline level minus the total oxygen normally consumed at rest for an equivalent duration.

The recovery curves illustrate two fundamentals of EPOC:

1. **Fast component:** In low-intensity, primarily aerobic exercise with little increase in body temperature, about half of the total EPOC occurs within 30 seconds; complete recovery requires several minutes.

2. **Slow component:** A second slower phase occurs in recovery from more strenuous exercise (often accompanied by considerable increases in blood lactate and body temperature). The slower phase of recovery, depending on exercise intensity and duration, may require 24 hours or more before re-establishing the pre-exercise oxygen uptake.

Metabolic Dynamics of Recovery Oxygen Uptake
Hill and others discussed the dynamics of metabolism in exercise and recovery as the body's carbohydrate stores to energy "credits," and thus, expending stored credits during exercise would incur a **"debt."**
The larger the energy "deficit" (use of available store energy credits) meant the larger the energy debt. The recovery oxygen uptake thus represented the added metabolic cost of repaying this debt, establishing the term "**oxygen debt."**

Hill hypothesized that lactate accumulation during the anaerobic component of exercise represented the use of stored glycogen energy credits. Therefore, the subsequent oxygen debt served two purposes:
(1) re-establish the original carbohydrate stores (credits) by resynthesizing approximately 80% of the lactate back to glycogen in the liver (gluconeogenesis via the Cori cycle) and
(2) catabolize the remaining lactate for energy through pyruvate–citric acid cycle pathways. ATP generated by this latter pathway presumably powered glycogen resynthesis from the accumulated lactate.

Implications of EPOC for Exercise and Recovery
Understanding the dynamics of recovery oxygen uptake provides a basis for optimizing recovery from strenuous activity.
Blood lactate does not accumulate considerably with either steady-rate aerobic exercise or brief 5- to 10-second bouts of all-out effort powered by the intramuscular high-energy phosphates.
Recovery, reflecting the fast component proceeds rapidly, enabling exercise to begin again with only a brief pause.
In contrast, anaerobic exercise powered mainly by rapid glycolysis causes lactate build-up and significant disruption in physiologic processes and the internal environment.
This requires considerably more time for complete recovery (slow component). Incomplete recovery in basketball, hockey, soccer, tennis, and badminton hinders a performer when pushed to a high level of anaerobic metabolism.

Procedures for speeding recovery from exercise can classify as:

Active recovery (often called "cooling down" or "tapering off") involves sub maximum aerobic exercise performed immediately after exercise. Many believe that continued movement prevents muscle cramps and stiffness and facilitates the recovery process.

In **passive recovery,** in contrast, a person usually lies down, assuming that inactivity during this time reduces the resting energy requirements and "frees" oxygen for metabolic recovery.

Modification of active and passive recovery have included cold showers, massages, specific body positions, ice application, and ingesting cold fluids.

Optimal Recovery from Steady-Rate Exercise

Most people can easily perform exercise below 55% to 60% of VO2max in steady rate with little or no blood lactate accumulation.
The following occur during recovery from such exercise:
1. Resynthesis of high-energy phosphates.
2. Replenishment of oxygen in the blood.
3. Replenishment of bodily fluids
4. Replenishment of muscle myoglobin.
5. Resupply of the small energy cost to sustain an elevated circulation and ventilation.

Passive procedures produce the most rapid recovery in such cases because exercise elevates total metabolism and delays recovery.

Optimal Recovery from Non–Steady-Rate Exercise

Exercise intensity that exceeds the maximum steady-rate level causes lactate formation to accumulate because its formation exceeds its rate of removal. As work intensity increases, the level of lactate increases sharply, and the exerciser soon feels "exhausted."
Active aerobic exercise in recovery accelerates lactate removal.

Intermittent Exercise and Recovery: The Interval Training Approach

One can exercise at an intensity that normally proves exhausting within 3 to 5 minutes using preestablished spacing of exercise-to-rest intervals. This approach forms the basis of the **interval training** program. From a practical perspective, the exerciser applies various work-to-rest intervals using "super maximum" effort to overload the specific systems of energy transfer.
Rapid recovery ensues (fast component), and exercise can begin again after only a brief recovery.

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