# Notes on difference between isometric and isotonic exercises, and carbohydrate loading

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## Difference Between Isometric and Isotonic Exercises

Exercises can be classified based on the engaged muscle's length and tension. Isotonic exercises involve an eccentric or lowering phase, and a concentric or lifting phase. Isometric exercises are those that have no joint movement but tension is developed within the muscle to support a load. Isometric exercises can be used to develop strength, muscle size and muscular endurance while isotonic exercises are generally better for increasing functional strength.

### Isometric

The isometric exercises are static or still exercises. When someone performs an isometric exercise, he does not move or put the muscle(s) through any range of motion. He simply holds a pose for as long as he can. Examples include: holding a static pushup position; holding a dumbbell in one hand mid bicep curl, or pushing against an immovable object, such as a wall.

### Isotonic

Isotonic exercises are the exact opposite of isometric exercises. When someone performs an isometric exercise he moves and is working his muscle(s) through a range of motion. Isometric exercises are actually the most common type of strength training exercises. For example, lifting weights, calisthenics, swimming, rock climbing, cycling etc.

Isotonic and isometric exercises have their own specific purposes. For example, when someone is doing an isometric exercise, he is only strengthening the muscle in the position it is being held. That type of training can be very beneficial to athlete, such as a gymnast, who has to support their bodyweight in awkward positions or hold them self in one position for a long time.

On the other hand, an isotonic exercise like weightlifting strengthen the muscles through a range of motion but not in the way of stamina and endurance.

Both types of exercises, however, can increase the amount of force the muscles can generate.

### Isotonic Vs. Isometric Muscle Exercises

During exercise, muscles can develop tension while shortening, lengthening or staying the same length. Muscle shortening, known as concentric contraction, forces a joint angle to decrease. Muscle lengthening, known as eccentric contraction, causes a joint angle to increase. When tension develops in a muscle but the length does not change, the joint does not move, and the contraction is said to be isometric. When comparing isotonic to isometric exercise, you are comparing exercises that respectively initiate joint movement to exercises that are static, causing no movement.

### Isotonic Exercise (DCER)

Isotonic exercise, also known as dynamic constant external resistance, (or DCER) for short, encompasses exercises where muscle tendons pull against bone to cause joint movement. Any moving exercise, from weight training to rowing or running, falls into this category. Isotonic exercise increase strength or improve performance. Because most human activity and athletic performance involve movement, isotonic exercise is foundational to most training protocols.

**Isometric Exercise**

Isometric exercises are static, meaning no joint movement is involved. The training effect of isometric exercise is specific to the joint angle at which it is performed. Strength adaptations from isometric exercise are a function of the length of time the body is held in position.

## Carbohydrate loading

Carbohydrate loading, commonly referred to as carb-loading or carbo-loading, is a strategy used by endurance athletes, such as marathon runners, to maximize the storage of glycogen (or energy) in the muscles.

Muscle glycogen levels are normally in the range of 100-120 mmol/kg ww (wet weight). Carbohydrate loading enables muscle glycogen levels to be increased to around 150-200 mmol/kg. This extra supply of carbohydrate has been demonstrated to improve endurance exercise by allowing athletes to exercise at their optimal pace for a longer time.

**Purpose**

Any physical activity requires carbohydrates to provide fuel. For most recreational activity, our body uses its existing energy stores for fuel. But when we engage in long, intense athletic events, our body needs extra energy. The purpose of carbohydrate loading is to give the energy to complete an endurance event with less fatigue, improving athletic performance.

Carbohydrate loading is most beneficial for an endurance athlete — such as a marathon runner, swimmer or cyclist — preparing for an event that will last 90 minutes or more.

For many endurance athletes the foods of choice for carbo-loading are those of low glycemic indices due to their minimal effect on serum glucose levels. Low glycemic foods commonly include fruits, vegetables, whole wheat and grains.

**The process - two steps to carbohydrate loading**

Traditionally, carbohydrate loading is done in two steps the process begins six days prior to a competition,

- For the first three days the athlete consumes minimal carbohydrate and exercises so as to deplete the bodies glycogen stores
- In the last three days the athlete consumes primarily carbohydrate and reduces the training load

**Sample carbohydrate-loading meal plan**

The following diet is suitable for a 70kg athlete aiming to carbohydrate load:

| | |
|---|---|
| Breakfast | 3 cups of low-fibre breakfast cereal with 11/2 cups of reduced fat milk<br>1 medium banana<br>250ml orange juice |
| Snack | toasted muffin with honey<br>500ml sports drink |
| Lunch | 2 sandwiches (4 slices of bread) with filling as desired<br>200g tub of low-fat fruit yoghurt<br>375ml can of soft drink |
| Snack | banana smoothie made with low-fat milk, banana and honey<br>cereal bar |

| | |
|---|---|
| Dinner | 1 cup of pasta sauce with 2 cups of cooked pasta<br>3 slices of garlic bread<br>2 glasses of cordial |
| Late Snack | toasted muffin and jam<br>500ml sports drink |

**[Transient hypoglycemia**

Carbohydrate ingestion less than 2 hours prior to aerobic exercise triggers elevated levels of insulin in the blood, which may dramatically decrease serum glucose levels. This can limit aerobic performance, especially in events lasting longer than 60 minutes. This is known as transient or reactive hypoglycemia, and can be a limiting factor in athletes. Individuals susceptible to hypoglycemia are especially at risk for elevated insulin responses and thus will likely suffer from performance-limiting transient hypoglycemia.]

## Anaerobic power

Anaerobic power is energy that is stored in muscles and that can be accessed without the use of oxygen. There are two systems that utilize this type of power, the phosphogen system and the lactic acid system. Human beings use this form of energy in short bursts that cannot be sustained for longer than about two minutes.

The human body produces energy in two ways:

1. Aerobically and
2. Anaerobically.

Aerobic power, which is the body's primary energy system, relies on oxygen that is transported through the respiratory and circulatory systems. Humans use aerobic power for most activities, from strolling through the park to running in a marathon.

Anaerobic power, on the other hand, is generated without the use of oxygen. It is utilized only when the body is being pushed as hard as it can go, in short, but powerful movements, such as while sprinting, jumping or swinging a golf club.

Anaerobic power is stored in muscle tissue in the form of adenosine triphosphate (ATP). There is only about one to four seconds worth of ATP available after that, the phosphate creatine (PC) system kicks in, which can synthesize additional ATP for as long as another 15 seconds. After this, the lactic acid system, or glycosis system, starts up and produces energy by breaking down carbohydrates. While these systems are running, the body is using more energy than it can replenish, and this can lead to cramping, fatigue and lactic acid buildup.

## Static & Dynamic work

Work can be thought of simply as activity - either mental or physical. We carry out mental work whenever we use our brain to do something - reading, watching television, solving a problem, etc. We carry out physical work whenever use our body to do something - walking, sitting, lifting, etc. Our body still works when we are asleep to digest food, repair tissues, keep breathing, etc.

**Types of physical work:**

Physical work is carried out by muscles and is therefore often called muscular work.

It is oftwo types:

**Static** (or *isometric* meaning 'same length'): in this type of work a muscle remains contracted for a period of time but there is no movement, as in holding a picture against the wall or carrying a bag of shopping. Holding a static or fixed posture can be very tiring as our muscles don't get time to relax. A muscle which is heavily contracted squeezes against the blood vessels next to it, restricting blood flow. This cuts down the delivery of oxygen to the muscle and the removal of a waste product, lactic acid, from the muscle. This results in muscular aches or pain. Any fixed posture will bring on these symptoms, for example, standing to attention or sitting upright.

**Dynamic** (or *isotonic* meaning 'same tension'): in this type of work there is rhythmical contraction and relaxation of a muscle which does result in movement, as in pulling open a drawer or walking up stairs.

Dynamic work is less tiring and more efficient than static work. This is because during dynamic work a muscle contracts and relaxes rhythmically which makes it act like a pump for the flow of blood in the blood vessels, allowing the blood to supply more oxygen and take away more lactic acid than during static work.

**Dynamic work**

In dynamic work, active skeletal muscles contract and relax rhythmically. The blood flow to the muscles is increased to match metabolic needs. The increased blood flow is achieved through increased pumping of the heart (cardiac output), decreased blood flow to inactive areas, such as kidneys and liver, and increased number of open blood vessels in the working musculature. Heart rate, blood pressure, and oxygen extraction in the muscles increase linearly in relation to working intensity. Also, pulmonary ventilation is heightened owing to deeper breathing and increased breathing frequency. The purpose of activating the whole cardio-respiratory system is to enhance oxygen delivery to the active muscles. The level of oxygen consumption measured during heavy dynamic muscle work indicates the intensity of the work. The maximum oxygen consumption $(VO_{2max})$ indicates the person's maximum capacity for aerobic work. Oxygen consumption values can be translated to energy expenditure (1 litre of oxygen consumption per minute corresponds to approximately 5 kcal/min or 21 kJ/min).

In the case of dynamic work, when the active muscle mass is smaller (as in the arms), maximum working capacity and peak oxygen consumption are smaller than in dynamic work with large muscles. At the same external work output, dynamic work with small muscles elicits higher cardio-respiratory responses (e.g., heart rate, blood pressure) than work with large muscles.

**Static work**

In static work, muscle contraction does not produce visible movement. Static work increases the pressure inside the muscle, which together with the mechanical compression occludes blood circulation partially or totally. The delivery of nutrients and oxygen to the muscle and the removal of metabolic end-products from the muscle are hampered. Thus, in static work, muscles become fatigued more easily than in dynamic work.

The most prominent circulatory feature of static work is a rise in blood pressure. Heart rate and cardiac output do not change much. Above a certain intensity of effort, blood pressure increases in direct relation to the intensity and the duration of the effort. Furthermore, at the same relative intensity of effort, static work with large muscle groups produces a greater blood pressure response than does work with smaller muscles.

The regulation of ventilation and circulation in static work is similar to that in dynamic work, but the metabolic signals from the muscles are stronger, and induce a different response pattern.

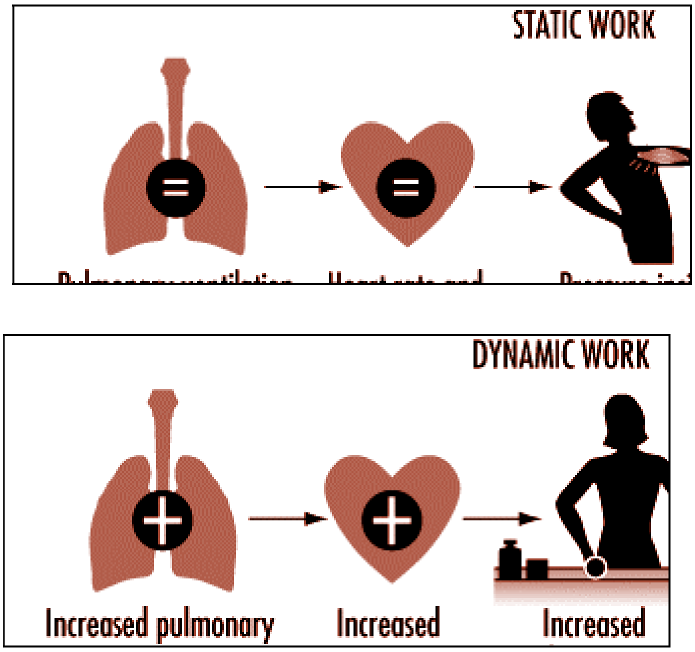


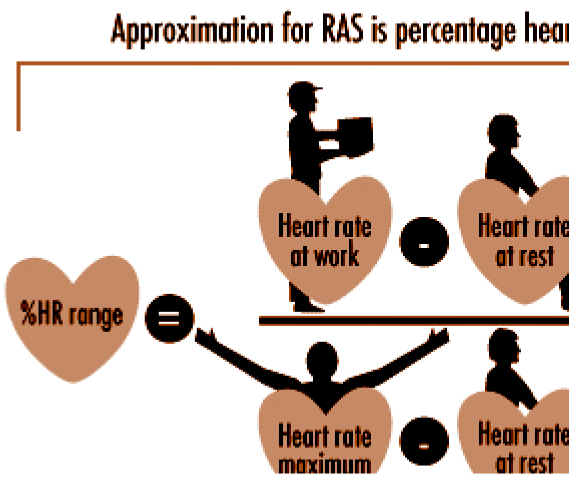

*Figure*: Static versus dynamic work

**[Acceptable Workload in Heavy Dynamic Muscular Work**

The assessment of acceptable workload in dynamic work is based on measurements of oxygen consumption (or, correspondingly, energy expenditure). Oxygen consumption can be measured in the field with portable devices (e.g., Douglas bag, Max Planck respirometer, Oxylog, Cosmed), or it can be estimated from heart rate recordings, which can be made reliably at the workplace, for example, with the SportTester device.

**Relative aerobic strain (RAS):** is defined as the fraction (expressed as a percentage) of a worker's oxygen consumption measured on the job relative to his or her $VO_{2max}$ measured in the laboratory. If only heart rate measurements are available, a close approximation to RAS can be made by calculating a value for percentage heart rate range (% HR range) with the Karvonen formula.

**Analysis of acceptable workloads**

$VO_{2max}$ is usually measured on a bicycle ergometer or treadmill, for which the mechanical efficiency is high (20-25%). When the active muscle mass is smaller or the static component is higher, $VO_{2max}$ and mechanical efficiency will be smaller than in the case of exercise with large muscle groups. For example, it has been found that in the sorting of postal parcels the $VO_{2max}$ of workers was only 65% of the maximum measured on a bicycle ergometer, and the mechanical efficiency of the task was less than 1%. When guidelines are based on oxygen consumption, the test mode in the maximal test should be as close as possible to the real task. This goal, however, is difficult to achieve.

According to Estrand's (1960) classical study, RAS should not exceed 50% during an eight-hour working day. In her experiments, at a 50% workload, body weight decreased, heart rate did not reach steady state and subjective discomfort increased during the day. She recommended a 50% RAS limit for both men and women. Later on she found that construction workers spontaneously chose an average RAS level of 40% (range 25-55%) during a working day. Several more recent studies have indicated that the acceptable RAS is lower than 50%. Most authors recommend 30-35% as an acceptable RAS level for the entire working day.

Originally, the acceptable RAS levels were developed for pure dynamic muscle work, which rarely occurs in real working life. It may happen that acceptable RAS levels are not exceeded, for example, in a lifting task, but the local load on the back may greatly exceed acceptable levels. Despite its limitations, RAS determination has been widely used in the assessment of physical strain in different jobs.

In addition to the measurement or estimation of oxygen consumption, other useful physiological field methods are also available for the quantification of physical stress or strain in heavy dynamic work. Observational techniques can be used in the estimation of energy expenditure (e.g., with the aid of the *Edholm scale*) (Edholm 1966). *Rating of perceived exertion* (RPE) indicates the subjective accumulation of fatigue. New ambulatory blood pressure monitoring systems allow more detailed analyses of circulatory responses.

**Acceptable Workload for Static Muscular Work**

Static muscular work is required chiefly in maintaining working postures. The endurance time of static contraction is exponentially dependent on the relative force of contraction. This means, for example, that when the static contraction requires 20% of the maximum force, the endurance time is 5 to 7 minutes, and when the relative force is 50%, the endurance time is about 1 minute.

Older studies indicated that no fatigue will be developed when the relative force is below 15% of the maximum force. However, more recent studies have indicated that the acceptable relative force is specific to the muscle or muscle group, and is 2 to 5% of the maximum static strength. These force limits are, however, difficult to use in practical work situations because they require electromyographic recordings.]

## Training Principles

Training to improve an athlete's performance obeys the following principles:

- Individuality principle
- Specificity principle
- Overload principle
- Recovery principle
- Adaptation principle
- Progression principle
- Variation principle
- Diminishing returns principle
- Reversibility principle

**Individual Differences Principle**

Every athlete is different and responds differently to the same training activities. The value of training depends in part on the athlete's maturation. Before puberty, training is less effective than after puberty. Other factors that affect how athletes respond to training include their pretraining condition; genetic predisposition; gender and race; diet and sleep; environmental factors such as heat, cold, and humidity; and of course motivation. It is essential to individualize training as much as possible.

**Specificity Principle**

The specificity principle asserts that the best way to develop physical fitness for sport is to train the energy systems and muscles as closely as possible to the way they are used in the sport. Thus, the best way to train for running is to run, for swimming is to swim, and for weightlifting is to lift. In Sports such as basketball, baseball, and soccer, the training program should not only overload the energy systems and muscles used in that sport, but should also duplicate similar movement patterns. For example, in strengthening a quarterback's throwing arm, design the exercise to simulate the throwing movement. Evidence suggests that cross training, or doing another sport or activity, can help improve performance.

**Overload Principle**

To improve the fitness levels, athletes must do more than what their bodies are used to doing. When more is demanded, within reason, the body adapts to the increased demand. Overload can be applied in duration, intensity, or both. If a cross country runner's long-distance run is increased by five minutes, an overload of duration is added. If the runner is asked to run the normal distance in a shorter amount of time, overload of intensity is added.

**Recovery**

The body cannot repair itself without rest and time to recover. Both short periods (like hours) between multiple sessions in a day and longer periods (like days or weeks) to recover from a long season are necessary to ensure the body does not suffer from exhaustion.

**Adaptation**

Adaptation occurs during the recovery period after the training session is completed.

If exercises lasting less than 10 seconds (ATP-CP energy system) are repeated with a full recovery (approximately 3 to 5 minutes) then an adaptation in which stores of ATP and CP in the muscles are increased. This means more energy is available more rapidly and increases the maximum peak power output. If overloads are experienced for periods of up to 60 seconds, with a full recovery, it is found that glycogen stores are enhanced.

The rate of adaptation depends on the volume, intensity and frequency of the exercise sessions. Recent investigation reports that 6 weeks of low-volume, high-intensity sprint training induced similar changes in selected whole-body and skeletal muscle adaptations as traditional high-volume, low-intensity endurance workouts undertaken for the same intervention period. Hawley (2008) states that the time of adaptation may be quicker for high-intensity sprint training when compared to low-intensity endurance training, but that over a longer period, the two training regimens elicit similar adaptations.

**Progression Principle**

To steadily improve the fitness levels of athletes, the physical demands must continually be increased to overload their systems. If the training demand is increased too quickly, the athlete will be unable to adapt and may break down. If the demand is not adequate, the athlete will not achieve optimal fitness levels.

**Variation Principle**

This principle has several meanings. After the athletes have trained hard for several days, they should train lightly to give their bodies a chance to recover. This principle also means that the trainee should change the exercises or activities regularly so that he/she does not overstress a part of the body. Some variety that involves the same muscle groups is a useful change.

**Diminishing Returns Principle**

When unfit athletes begin training, their fitness levels improve rapidly, but as they become fitter, the diminishing returns principle becomes law. That is, as athletes become fitter, the amount of improvement is less as they approach their genetic limits. A corollary to this principle is that as fitness levels increase, more work or training is needed to make the same gains.

**Reversibility or Detraining**

Improved ranges of movement can be achieved and maintained by regular use of mobility exercises. If an athlete ceases mobility training, his/her ranges of movement will decline over time to those maintained by his/her other physical activities.

When training ceases the training effect will also stop. It gradually reduces at approximately one third of the rate of acquisition. Athletes must continue strength training throughout the competitive period, although at a much reduced volume, or newly acquired strength will be lost.

## Mitral stenosis

Mitral stenosis is a valvular heart disease characterized by the narrowing of the orifice of the mitral valve of the heart. The mitral valve separates the upper and lower chambers on the left side of the heart. Stenosis is a condition in which the valve does not open fully, restricting blood flow.

**Symptoms**

In adults there may be no symptoms. However, symptoms may appear or get worse with exercise or any activity that raises the heart rate. In adults, symptoms usually develop between ages 20 and 50.

Symptoms may include:

- Chest discomfort-
  - Increases with activity, decreases with rest
  - Radiates to the arm, neck, jaw, or other areas
- Bloody caugh (hemoptysis)
- Difficulty breathing during or after exercise
- Fatigue - becoming tired easily
- Frequent respiratory infections such as bronchitis
- Sensation of feeling the heart beat (palpitations)
- Swelling of feet or ankles

In infants and children, symptoms may be present from birth (congenital), and almost always develop within the first 2 years of life. Symptoms include:

- Cough
- Poor feeding or sweating when feeding

**Causes**

Causes of mitral valve stenosis include:

- **Rheumatic fever:** Rheumatic fever is the most common cause of mitral valve stenosis. It can damage the mitral valve in two ways. The infection may cause the leaflets of the valve to thicken, limiting the valve's ability to open. Or the infection may cause the leaflets of the mitral valve to fuse somewhat together, preventing the valve from opening and closing properly.
- **Congenital heart defect:** In rare cases, babies are born with a narrowed mitral valve and develop mitral valve stenosis early in life. Others are born with a damaged mitral valve that may cause mitral valve stenosis in older life.
- **Other causes:**

a. Blood clots or tumors can block the mitral valve causing mitral valve stenosis.
b. Excessive calcium deposits can build up around the mitral valve sometimes causes significant mitral valve stenosis.
c. Radiation treatment to the chest and some medications also may cause mitral valve stenosis.
d. Endomyocardial fibroelastosis, malignant carcinoid syndrome.

**Consequence:**

Mitral valve stenosis can weaken the heart and decrease the efficiency of pumping the blood. Mitral valve stenosis can lead to complications such as:

- **Heart failure.** Heart failure is a condition in which the heart can't pump enough blood to meet the body's needs. A narrowed mitral valve interferes with blood flow through heart and from heart out to the rest of the body. In addition, pressure builds up in the lungs leading to fluid accumulation.
- **Heart enlargement.** The pressure buildup of mitral valve stenosis results in enlargement of heart's upper left chamber (atrium). At first this change helps heart pump more efficiently, but eventually, it

damages heart's overall health. Additionally, pressure can build up in the lungs and cause pulmonary congestion and hypertension.

- **Atrial fibrillation.** In mitral valve stenosis, the stretching and enlargement of heart's left atrium may lead to a heart rhythm irregularity called atrial fibrillation. In atrial fibrillation, the upper chambers of heart beat chaotically and too quickly.
- **Blood clots.** Atrial fibrillation can cause foramtion of blood clots in the upper left chamber of heart. Blood clots from heart may break loose and travel to other parts of the body, causing serious problems. For example, a blood clot that travels to the brain and blocks a blood vessel could cause a stroke.
- **Lung congestion.** Another possible complication of mitral valve stenosis is pulmonary edema — a condition in which blood and fluid back up into the lungs. This causes congestion of the lungs, leading to shortness of breath and, sometimes, coughing up of blood-tinged sputum.

## Muscle Power & Muscle Strength

**Muscle Power:**

Power is defined as the ability to generate as much force as fast as possible. Power is needed for athletic movements such as swinging a baseball bat, olympic clean and jerk, and a golfer's swing.

Power = Work/Time

For example, using the 315 pound bench press from above, if it took 3 seconds to perform the repetition, the equation would look like this:

315 units of work/3 seconds = 105 units of power

**Muscle Strength:**

Strength, on the other hand, is defined as the ability to generate as much force as possible with no concern for how long it takes to perform the exercise. Strength is most important to weight lifters who are trying to perform their one rep maxes such as bench press, deadlift and squat.

Strength = Mass x Distance

For example, a 315 pound bench press that moves 2.5 feet would look like this:

315lbs x 2.5 feet = 787.5 units of work