Forum:Seminar papers/Biophysics/2. LF/2018-2019/Group 3/DEFK

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Signature: Carmeljcaruana (talk)

ERGOMETRY

Introduction

Ergometry is that part of biophysics that deals with the parameters that change during a physical activity carried out by a person. It provides information for example on which muscle or muscle group is being used and how it affects the performance of the person during the exercise being carried out. An ***ergometer*** is a physical device that measures the amount of work performed by a person connected to the device during say an exercise workout (for example: Cycle Ergometer or Monark Arm ergometer)

Background

In physics, work is defined as the force used multiplied by the distance that it is applied and its unit is the Nm or Joule (J),**(i.e, W(J)** =**F (N)**x**D(m))**. Work in Ergometric experiments is equal to the chemical energy from the body converted to mechanical potential or kinetic energy during the exercise. Another important quantity is **Power,** which is the work carried out per unit time, given by the following formula: P(Watt)=W(Joules)/t (seconds). Ergometry can be used to better understand the amount of ***energy expenditure of the body***, and the ***energy cost*** of performing specific exercises on ergometers. To illustrate that, performing cycle ergometry at a power of 1250 J/min for 45 min gives 562.5 kJ (12.5 kJ/min x 45 min). (an old unit of energy is the calorie and 1kJ = 239 calories). However it is important to note that in fact the body would have expended more energy than this (the total energy spent is called the Biological Expenditure BE) as it heats up during the exercise and so there is also energy converted to heat. Hence the body does not convert all BE into potential or kinetic energy in the ergometer. The body does not have 100% efficiency.

Clinical Importance

Ergometry is employed in various fields of medicine that include mainly Cardiology and Sports medicine.

In cardiology, ergometry is used for cardiac performance evaluation, for the diagnosis of hypertension and for monitoring any ongoing blood pressure therapy. It is also used to diagnose disturbances of the cardiac rhythm under exercise and to determine an optimal training pulse. Ergometry or stress ECG is usually carried out on a bicycle ergometer where the patient is loaded in a defined manner and the blood pressure and heart rate are recorded and displayed graphically to be analyzed by a cardiologist.

In sports medicine such as cycling performance, the ***Isokinetic Cycle Ergometer*** allows to carry out time and position analyses for effective pedal force and power produced at various revolution rates. The Isokinetic Cycle Ergometer is applied as an effective means for the improvement of strength of lower extremities in patients as well as in competitive cyclists.

Literature Review

Ergometers have several advantages and disadvantages depending on the type of exercise machine or Ergometer used. For instance, bicycle ergometers are very effective for exercising the thigh muscles, good for the joints, do not put a lot of strain on the knees, and well suited for endurance exercise. However, as compared to a treadmill, a bicycle ergometer induces a lower increase in heart rate and systolic blood pressure, but these two quantities are crucial for ergometric study.

Cardiorespiratory endurance: is the ability to perform large-muscle, dynamic, moderate-to-high-intensity exercise for a prolonged period of time. High levels of cardiorespiratory fitness are associated with lower risk of disease. Cardiorespiratory endurance can be tested in a number of ways, and each has advantages and disadvantages.

Endurance tests are **submaximal tests**. **Maximal tests** require specialized equipment that measures how much oxygen you use and the amount of carbon dioxide you exhale while monitoring heart rate and blood pressure. It is complicated, requires trained professionals, and sometimes needs a physician present. It requires an all-out effort from you. A submax test can give a good representation of your current fitness level without all of the fancy equipment and with a lower risk to your body.

Treadmill Tests: A treadmill is a tool that is used for testing endurance, and it can help assess your fitness level. They are common to fitness centers, and the tests are relatively easy to administer. The tests on the treadmill are either walking or running tests, so there is no special training for participants. However, treadmills can be costly, so unless you are at a gym, you may not have access to one. Also, you need to consider your limitations. If you are obese or have musculoskeletal issues, walking or running for an extended period of time may not be an option.

Cycle Ergometer Tests: Cycling may be a better choice for those participants who have joint pain or other health issues. No special training is required, and the activity is non-weight bearing. It is also less expensive than a treadmill. However, the protocols are a little more in-depth, so you need an experienced person to administer the test. Also, if you are obese, you must make sure that the bike can hold your weight.

Field tests that are cheap and easy to administer, and that can cater to multiple test objects (people in this case) can be accommodated in the experiment. Often all you need is a stopwatch and a track, or another known well measured outdoor space. These tests are administered walking or running, so you should be able to do one of these activities. In a field test, you are required to cover a given distance in the shortest amount of time possible. You might be tempted to push yourself to near max effort, so use caution. Field tests are not as accurate as submax protocols, but they can provide an overview of health and fitness status.

Equipment

For this experiment the Kettler's ergometer (pictures below), has been selected. Here are the steps to be performed in order to carry out the experiment:

• Patient's Details: Fill in the patient's details: Day of birth/ Weight (kg)/Sex/ Rpulse – the resting heart rate (bpm).

• System Settings: Evaluation Standard chosen by the experimenter e.g., energy achieved in a certain time or energy used until subject can no longer turn the ergometer etc set the system (e.g., time, speed..)

• Let the subject be on the ergometer and measure the heart rate:

(a) With ear clip:The pulse sensor works with infrared light and measures the alterations of the translucency of your skin, which are caused by your pulse beat. Before you clamp the pulse sensor to your earlobe, rub the earlobe well to increase circulation.

(b) With hand sensors: the voltage generated by the contraction of the heart is recorded by the hand sensors and analyzed by the electronic equipment. Always grip the contact surfaces FIRMLY with both hands.

• Beginning to pedal starts the training based on the system setting. The displays for pedal rotations, speed, distance, energy and time count upwards. The patient must pedal till the Evaluation Standard is satisfied.

• Training break or ending the session Stop pedaling. If the pedal rotations fall below 10 rpm, this is recognized as being a training break. The average values for speed, rpm, power and heart rate (if heart rate recording is active) are displayed with the Ø AVG symbol and the total values for distance, energy and time are also displayed.

• Analysis of the result with Guide Values

Measurements and calculations:

The Ergometer calculates the work done by simply multiplying the force applied by the human body and the distance occurred during that time. You would see that the distance is shown on the dashboard. It is calculated by counting how much the belt in the equipment is moving. Once you start cycling, the equipment calculates the force you apply to the pedal and the distance you pedal. The instrument measures the work done by multiplying the force and the distance.

The quantity we want to derive from an Ergometer is the biological energy expenditure (BE) that is the total energy used up during the exercise. But the value measured directly from the Ergometer is only the energy transferred from the body to the machine as potential or kinetic energy (Mechanical Energy ME = work done) and does not include the heat produced in the body itself during the exercise. However, if we know the efficiency of the body during exercise, we can calculate the value of BE from the measured ME using the formula: BE = ME / efficiency

Pictures

Conclusion

Ergometry is a crucial contributor to the improvement of health sciences. In addition to Cardiology and Sports Medicine, Ergometry is also used in the field of Psychology. In a research done by the Department of Psychology of New York University by Gabriel Oettingen and Peter M. Gollwitzer, a bicycle ergometer test was used as a tool to prove their theory that people selectively set goals that are desirable and then strive to achieve them. Also, according to various researchers in health sciences, it is predicted that in the future standardized, comparable, and reproducible ergometry will be applied widely in scientific and practical medicine.

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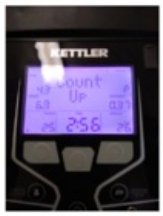

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