Ergometry Practical

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ERGOMETRY

Introduction

Ergometry is the science that measures amounts of work activity. To be more specific, ***Ergometry*** is the study of physical work done by the body, especially that performed by a specific muscle or muscle groups during exercise. An ***Ergometer*** is a device that measures work performed by a person exercising. In other words, an Ergometer is an exercising machine, such as a Cycle Ergometer or Monark Arm ergometer attached to a device that measures mechanical work done.

By definition, **work** (**unit: J = Nm**) is the **force F (unit: Newton) applied multiplied by the distance (unit: m) W=FxD**. Work is equal to the body energy converted to heat energy in the ergometer. Another important value is **Power** which is work per unit time, given by the following formula: P=W/T. Ergometry can be used to better understand the ***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). 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 Energy Expenditure BE) as it heats up during the exercise. Hence the body does not convert all BE into work on the ergometer. The body does not have 100% efficiency.

Importance in Clinical medicine

Over the past decade, clinicians have focused on more expensive tools for improved diagnosis with optimal accuracy. In fact, simple exercise test, with the incorporation of historical data, can outperform those new expensive tests. Ergometry is employed in various fields of medicine that include mainly Cardiology and Sports medicine.

In cardiology, ergometry is used for performance diagnosis, for the diagnosis of hypertension and for monitoring any ongoing blood pressure therapy. It is also used to diagnose disturbances 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, the ***Isokinetic Cycle Ergometer*** allows to carry out the time and position course analyses of 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 our 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 one tool that is used for testing endurance, and it can help predict 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 more than one person at a time can be tested. Often all you need is a stopwatch and a track, or another premeasured 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

Kettler’s ergometer and Operating buttons (see FIGURES below).

Protocol (Preparation for examination)

1 Patient’s Details

Enter the name of the team member volunteer to be investigated in the experiment and write it in the protocol. Fill in the relevant fields with gender, weight, age, resting heart rate (found best in the morning after waking up but in our case student should lie down and rest for 15 minutes) and information on whether the person in question is an athlete and indicate other reasons that could affect the results of the examination (current/permanent health problems, whether he/she is a smoker, ...).

2 System Settings

Push the Reset button on the ergometer. Based on Evaluation standard (e.g. Energy achieved by certain time / Energy calculated until subject could no longer turn the ergometer / Set the speed and compare the time the ergometer turned) set by the experimenter, set the system (e.g. time, speed..).

3 Let the subject be on the ergometer and calculate heart rate.

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 it well 10 times to increase circulation.

With hand pulse: An extra-low 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 with both hands • Avoid jerky gripping • Keep your hands still and avoid contractions and rubbing on the contact surfaces.

4 Select the ‘Count Down’ by repeatedly pressing the button ‘Program’.

5 Using the Set, - and + buttons, set the time to 15 min.

6 Click on “Set” until you get to the default screen.

7 Then check if the power (‘load’) is 20W, if not adjust the power using the buttons - and +.

8 After setting up the Ergometer, the volunteer to be examined puts the heart-rate monitor on the chest.

9 Begin to pedal starts the training Based on the system setting, Begin to pedal starts the training. The displays for pedal rotations, speed, distance, energy and time count upwards. Pedaling till the Evaluation standard is satisfied.

10 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.

11 Analysis of the result with Guide values.

Method of investigation: Increasing power (‘resistance’) without pauses

1. The examined person gets on the elliptical ergometer and stands still on it
2. Record the pulse-rate immediately before starting the examination.
3. For a period of 3 minutes, the examined person runs on the moving platform at a set power of 20W; approximately 10 seconds before the end of the third minute, read and write in your table: revolutions-per-

minute (RPM), speed, power, pulse-rate, distance, and energy expended.
4. Increase the power to 40W and run for another 3 minutes. Approximately 10 seconds before the end of the 3 minutes, read and write in your table: revolutions-per-minute (RPM), speed, power, pulse-rate, distance, and energy expended.
5. Proceed in a similar way, increasing the power by 20W every 3 minutes up to 100W, and before the end of any 3-minute period, read and write the above values in the table
6. Reduce the power back to 20W, run for another 3 minutes and again record the data in the table.
7. Resting Time: The examined person should sit and rest for another 3 minutes. Take the pulse reading at the end of the resting time.

Method of investigation: Increasing power ('resistance') with pauses

Repeat the above experiment however, use a 3-minute-run followed by a 1-minute pause instead of a 3-minute run at each power.

Compare the two sets of data (without and with pauses).

Measurements and calculations

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

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 forming implementation intentions is essential for goal striving. In other words, 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.

FIGURES

Fig. 1

Fig. 2

Fig. 3

Fig. 4

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