Palacky University in Olomouc
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PHYSIOLOGICAL ASPECTS OF NORDIC WALKING

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Abstract: The purpose of the present study was to measure impact of speed and slope on metabolic and cardiovascular load of organism during Ordinary and Nordic Walking using % of VO_2max and % HRR. In research we measured 10 people (all men) average age 26.9±3.5 years; BMI 23.7±2.2 $kg \cdot m^{-2}$; VO_2max 56±8 $ml \cdot kg^{-1} \cdot min^{-1}$. Both types of walking we did on treadmill on four speed (6.0; 6.6; 7.2; 7.8; $km \cdot h^{-1}$) and on three slopes (0; 5; a 7.5%). On each volunteer we did 24 measurements (12 with poles and 12 without them) in time of 15 min. The results show us that during walking with poles oxygen consumption is increased for 3.4 % and heart rate for 5.9 % HRR, what was statistically significant. Nordic Walking is very good for people who want to increase their energy expenditure during low physical activity.

Keywords: Nordic Walking, Ordinary Walking, heart rate, step rate, oxygen consumption, intensity of load....

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Abstrakt: Cílem výzkumu bylo sledovat a porovnat metabolické a kardiovaskulární zatížení organismu při běžné chůzi a nordické chůzi pomocí ukazatelů % VO_2max a % MTR. Výzkumný soubor tvořilo 10 probandů (10 mužů) průměrného věku 26,9±3,5 let; BMI 23,7±2,2 $kg \cdot m^{-2}$; VO_2max 56±8 $ml \cdot kg^{-1} \cdot min^{-1}$. Oba typy chůze byly provedeny na běžeckém páse při 4 rychlostech (6,0; 6,6; 7,2; 7,8; $km \cdot h^{-1}$) a při 3 sklonech (0; 5; a 7,5%). Každý dobrovolník podstoupil 24 měření (12 s holemi a 12 bez holí) v délce 15 minut. Výsledky ukázaly, že při chůzi s holemi došlo k nárůstu spotřeby kyslíku o 3,4 % a tepové frekvence 5,9 % z MTR, což bylo statisticky významné. Nordická chůze je tedy vhodná pro lidi, kteří chtějí zvýšit svůj energetický výdej během nenáročné pohybové aktivity.

Kličová slova: nordická chůze, běžná chůze, spotřeba kyslíku, tepová frekvence, intenzita zatížení...

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To the all participants in testing, for their cooperation

Lastly, I offer my regards to all of those who supported me in any respect during the completion of the project.

Declaration

I hereby declare that I have completed Master thesis independently under the supervision of prof. **RNDr.** Aleš Jakubec, **Ph.D.** I have provided all literal sources and met all principles of scientific ethics.

In Olomouc, January 2011 .....

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1. INTRODUCTION

Today's life brings us technological society with an increasingly negative impact on our health. The reason is bad life style and low physical activity and high caloric intake, causing May diseases of civilization, mostly obesity, diabetes and high blood pressure.

Many people do not realize that health is the most important thing in our life and that we have to do something to keep it. Active every day life of ours ancestors where they were doing hard jobs today is turns on easy jobs, mostly sitting at the computer, etc. And we do not need to do some big things to go away from every day stress and health complications. Only depends on us how much we will give to our health.

Our first and the simplest options how to keep our health is walking. That is most natural movement, unclaimed, which we can use in every day life and also people with some kind of healthy complication can use this activity. World Health Organization is recommended walking as a best way how to reduce weight.

One of the useful ways how to start with a walking as activity is physical activity called Nordic Walking. That is walking with using of special poles, what is helping us to increase our physical and psychological condition, to force muscles of the legs and also upper limbs, on that way will be improving of posture of the body and relive back pain and cervical spine.

Nordic walking is very great for beginners in sports, physically debilitated individuals and for persons in recovery. Can be recommended to all people no matter on sex, ages and physical condition of person. Intensity of exercise will reduce involvement of the upper limbs, allowing the common practice for people with different level of fitness. And that could be one of the reasons why is Nordic Walking becoming so popular in last couple years.

First time Nordic Walking was mention in Finland in the thirties of last century where they use this kind of activity as a part of summer training for ski runners. This physical activity became popular in recent years and was a huge boom. Because of that this physical activity became part of professional studies and researches, where they measure different impact of Nordic Walking (usually comparing with Ordinary Walking),

on human body, importance of the proper technique, testing of equipment, impact of environment etc.

My work is a part of laboratory research, who intends to examine effect of Nordic Walking on human organism. It is focused on explanation of difference between oxygen consumption during Nordic and Ordinary Walking. Also compare heart rate during both types of Walking. Results should show us that Nordic Walking is excellent physical activity which can improve our health and increase our physical condition.

2 LITERATURE REVIEW

2.1. Concept of Nordic Walking

Nordic walking increase effect and safety of movement, helps to include upper body muscles, adjusted a posture, alleviate back pain, relief pressure on joint, extending of possibilities of stretching and strength exercises, which should be part of every walking or every training unit. Poles for Nordic walking are very light, firmly and flexible and has all safety assumptions decaled with different modes of loading in the terrain (not only for walking but for different types of strength exercise (Vystrčil, 2005).

Other positive effect of using the poles are on psyche, allows managing the stress, loosing of psychological stress, detached from worry etc. Nordic walking can be way for creation social contacts and connecting.

As simple variation of the most natural human locomotion, walking is suitable for almost everyone. In comparison with same intensity of normal walking there was significant increase in oxygen consumption, energy expenditure and heart rate without increasing subjectively perceived exertion. That increase resulting is from the extensive involvement of the upper limbs and torso muscles (Churych, Ernest & Morss, 2002)

Using of poles has another purchase, for example reduce tension of neck muscles with a consequent significant increase in lateral mobility of cervical thoracic and lumbar spine. Then is regulated pressure of lower extremity joints by transferring part of the weight through the pole on the upper body. Poles increaser safety of movements, according to that elder people can use this type of activity during the whole year.

Most suitable environment for Nordic walking is forest path with a slightly rugged terrain, but qualitative training can be done even in the city (city parks).

2.2 History of Nordic walking

Nordic walking started in beginning of 20th century in Finland as a part of training during the summer, for cross country skiers. Nordic walking as physical activity for population appears 5. January 1988 in Helsinki where should be competition in cross country skiing. Because of deficit of snow, organizations were let alternatively solution. They started competition in Nordic walking. After that competition starts a lot of research about influence and advantages of Nordic walking. Progressively Nordic walking becomes favorite activity, not just for cross country skiers as a training (Karda 2008), but become a favorite activity in free time for people in Finland.

In middle 80's in United States of America was presenting walking with active pushing with poles towards recreation. That activity was called Exestride, exercising with strides

In 1992 in United States was first mention in literature of „Poles Walking“.

Original Nordic Walking can be a new form of very long steps conditional with strong use of poles very demanded sport. Technique became more and more as techniques in Cross Country skiing.

Nordic walking is one of the fastest growing exercise activities in the world.

2.3 Health and Nordic Walking

As has already be written Nordic Walking is very pleasant kind of movements, who can do anyone, high level athletes and beginners, young people and adults. Improves condition, strengthens the muscles of the upper body and legs and improves mobility of blood circulation.

Heart rate is on that area that we can feel good a lot of hours, and in the same time energy consumption is very high about 40%. Performance require from 600 muscles, what is about 90% of all body muscles. Most of citizens walk less then one mile per day. Because of that they should not wonder of a lot of problems be overweight, whose consequences are different disease of joints. Run for overweight people is very difficult

exercise. They can do Nordic Walking without any problems. Poles include all muscles of body and decreased pressure on legs joints. (Vystrčil, 2005)

2.4 Influence of Nordic walking on organism

- Increase heart rate about 5-17 per min
- Increase body calorie consumption thanks to movements with poles, about 20% more then during normal walking
- Burns 40% more calories then in ordinary walking
- Poles suppliers guarantee the smooth and slippery surface
- Helps to regulate weight, prevents of development of diabetes and certain cancers (for example cancer of colon)
- Decrease of high blood pressure and level of cholesterol
- Reduce risks of heart disease and heart stroke
- Increase of density of bones and helps to prevent beginning of osteoporosis
- Helps to reduce anxiety, induces feelings of euphoria
- Contribute to better brain oxygenation, improves memory
- Increase creativity and ability to solve a problem
- Including 90% of muscles in the body
- Ideal for back and shoulders muscles
- Save knees and reduce the pressure in people with overweight
- Better coordination of movements

2.5 Concept of Ordinary Walking

Walking is a power of moving over a surface with feet from place to place (Michael Bahr). For people walking present the most natural physical activity. Mostly we think that walking is everyday activity and we usually depreciate her physiological effect. There are not so much people who believe that with walking they can approach big influence on health. Walking is ideal physical activity, maybe intense exercises for those

who not resign driving in motor vehicles or do not like to spend time in gym, or to do some sports which require maximum discipline, big effort or special places.

We can walk everywhere, and the touch with the nature is healthiest than other sports. Movements which we are using during the walking are most natural movements and adapted to human body.

2.6. Phylogenies of Walking

Origin of walking in human's life is defined as phylogenies. The first lend vertebrates were moving on land the same as in the water, wave with trunk.

Quadruped animals during walking are using front and back spine muscles, extended steps and magnification of reflective power. They are fast and stable; their center of gravity is lower under the body between front and back limbs.

Bipedal walking is not so stabile and effectives quadruped. Center of gravity is higher, above base of support, because of that stability is lower. Speed of bipedal locomotion is lower because muscles are not used like in quadruped locomotion. Advantage of bipedal locomotion is that we are having two limbs free for doing some other things.

Picture 1

2.7 Physiology of Walking

For more reasons (like accessibility, no special equipment, possibility to do that with out other people), walking and running is the best and simplest physical activity (Stejskal, 2004).

Walking is basic physical activity which can be used in form of competition, recreation or as preventive and therapeutic activity.

Energy consumption is in big range, depends of the weight of person, walking speed, surface of ground and dip. With increasing of speed and weight becoming increasing of energy consumption, first linearly, but during the highest speed, energy consumption can increase rapidly which means that walking can be less economically.

Walking on the field depends of the kind of surface. When we are comparing walking on the grass, walking on the plowed field is 1.5 times required, in the hard snow 1.6 times, on the sand 1.8 times and on soft snow 3.0 times required. Walking up the stairs is considered as one with biggest energy consumption (Stejskal 2004).

During the walking with load it is always better to have it fixated on the body than on the legs or on foots. The same load increase about 8% if is on the legs and 1.4% if is on the body. It means that every 100g added on leg increase energy consumption about 1% Maček, 1997).

Walking simulate keeping of the vertical position and effectors of locomotion. Beside that during the walking is adequate dynamic and statics load of muscles, ligaments and skeleton of the legs and spine. If we are using walking correctly that can reduce risk of osteoporosis. React on blood circulation in organs in lower part of the body and stimulates circulation and respiratory system. Some of the risks of slow locomotion are possibilities of arthritics changes of joints, and possibilities of insufficiency of peripheral circulation – endema. During slow walking we should be prepared and to make space for regeneration. Much more frequently we are using walking with bigger speed till 6km per one hour.

Fast walking as a way of training of endurance has influence on blood circulation and organism. It is unclaimed, natural movement, with small load, can have intensive influence on training. Differences between normal and fast walking are not only in speed and bigger step rate, but in higher using of upper limbs. Advantage of walking when we are comparing with running where we have much more lactate on blood, is mostly covered with oxidative expenditure.

If we want to have some effect in changes in metabolism we should have endurance training at least 50% VO_2max, minimum three times per week, duration around 30 min. When intensity is low it should takes 45 min (Kračmar, 2002).

For elders or people who are not in good condition recommended speed of walking is 5 – 6.5 km/h. For healthy people in the middle ages with good physical conditions recommended speed is from 6.5 till 8 km/h. For young athletes speed should be more between 8 and 9.5 km/h.

2.8 Walking Technique

Human body has over six hundred muscles, and about half of them will be used we take first step. Some of them will not be moving, they are support or used in functions secondary to the walking motion. (Wendy Bumgardner, 2008)

Walking technique for treadmill, track or street is the same. Good posture, using arms properly and foot motion are the basic things for good power, and no wasted effort. With a good posture we will walk comfortably and easily, we will be able to breathe easier and avoid back pain.

- Back should be straight, do not lean forward or backward
- Eyes should looking rather 20 feet ahead, not looking down
- Chin should be parallel to ground because of reducing strain on neck and back
- Shoulders should be relaxed and slightly back
- Contraction of abdominal muscles
- Rotate of hips forward slightly

Arms motion can lend power to walking, burning 5-10% calories more. They are good balance to leg motion.

- Angle of elbow should be 90degrees
- Hands should be loose in partially closed curl
- The arm opposite our forward foot comes straight forward, not diagonally
- Elbows should keep close to our body
- When hand coming forward should be kept low, not higher then breastbone
- Every 5 or 10 min we should let arm rest

Walking steps is a rolling motion.

- Touch the ground first with heel
- Roll thought the step from hell to toe
- Push off with toe
- The back leg coming forward to strike again with heel

The stride should be longer behind our body, where our toe pushing off. Forward leg has no power, our back leg driving us forward. Fast walkers train themselves to increase the number of steps they take per second and to get full use out of the back part of stride.

2.9. Gait cycle

Frontward movements are composing from repeating steps in gait cycle. RLAH terminology divides the gait cycle into two phases, stance and swing. One gait cycle is measured in percents and proportion between phases is 60: 40.

Stance phase accounts 60% of gait cycle. This phase includes:

- Loading response, which is 0 to 10 percent of the gait cycle. Took time from initial contact until collateral toe off)
- Middle stance and terminal stance, which is from 10 to 50 percent of gait cycle. It is ending when the opposite foot contacts the ground
- Pre swing took from 50 to 60% percent of gait cycle. It is ending when the foot leaves the ground

Swing phase is 40% percent of the gait cycle and includes:

- Initial swing
- Middle swing
- Terminal swing

Each gait cycle includes two periods of single limb support and two periods of double limb support.

2.10. Types of Walking

2.10.1. Uphill Walking

Uphill walking can be done outdoor or on treadmill simulating an outdoor hill. There are also correct ways to do it that will prevent injury, and promote health.

During the uphill walking the posture must be erect. It is natural to lean into the hill a bit. Every lean will put stressful loads on back. While walking is better to simply slow down then leaning forward. Keeping of posture erect will be maximized the efficiency of breathing.

Stride can be short, medium or long. The best is to plane stride length during the walking uphill. Knees should not be lifted more then 6 inches. When slope is bigger stride length will need to be short even more.

Walking uphill can be done parentally sideways or completely sideways. That will recruit a different muscle pattern. Hands can be on hips or behind back or swinging at sides. They can be straight, slightly bent or very bent.

2.10.2 Downhill Walking

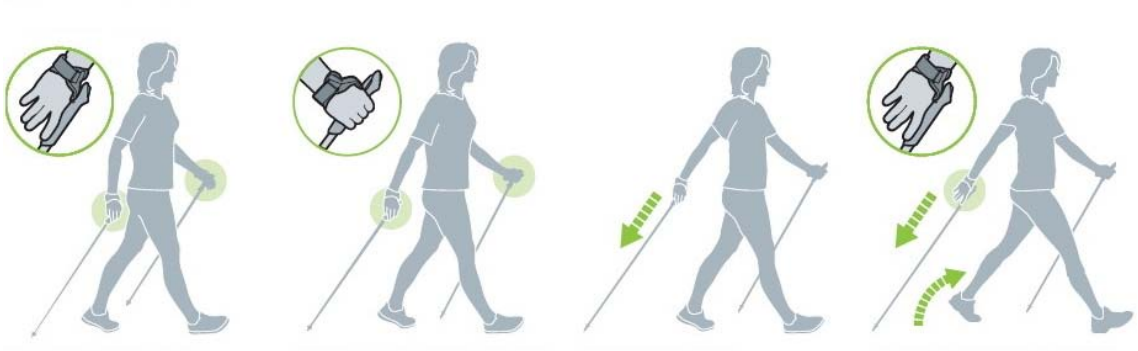
Walking downhill seems easy, but it is put more strain on knees and angles. If we are approach it in wrong way that can increase risk on joint damage. Research shows that downhill walking has surprising benefits in lowering blood sugar.

Posture is very important. Back should not be leaned, in counterpart that will send the body out of balance. Weight should be over hips. Knees should be slightly bent to absorb the shock and lower centre of gravity, thereby increasing stability.

Stride will be length automatically. If we want to control our speed stride will be shorten.

2.11. Nordic Walking Technique

Technique of walking with poles is basically simple. The most important is stride and his trample of heel. In Nordic waking stride is longer then in ordinary walking. The technique is a simple enhancement of normal arm swing during walking. The poles remain behind and pointing diagonally backwards at all times (picture 2).



Picture 2

- Shoulders are relaxed and down.
- Poles are held close to the body.
- The hands are opened slightly to allow the poles to swing forward, the poles are not gripped but swing from the wrist straps.
- The leading foot strikes he ground.
- The opposite arm swing forward to waist height.
- The opposite pole strikes the ground level with the heel of the opposite foot.
- The poles remind pointing diagonally backwards, they are never in front of the body.
- Push he pole as far as possible, the arm straightening to form a continuous line with the fully extended arm, the hand opening of the grip by the end of the arm swing (picture 3)

Picture 3

- The foot rolls through the step to push off with the toe. This lengthens the stride behind the body, getting the most out of each stride.
- The arm motion is loose and relaxed.

2.11.1. Uphill Walking

Picture 4

When walking uphill the body leans forward more then usual. The use of the arms is more powerful while the muscles at the back of the things and the calf muscles are also called upon to a greater extent. Vigorous use of the poles helps to lengthen the stride on inclines. Pole thrust on uphill sections spreads the load from the legs to the upper body. Uphill walking is excellent training for beginners as it helps learning the use of the arms (picture 4).

2.11.2 Downhill Walking

When walking downhill the stride is shortened and the center of gravity held lower. The knees are kept slightly bent the whole time an neither is the foot extended as it pushes off from the ground. The weight is shared between the pole striking the ground and the heel of the opposite foot. The more strain taken by the pole the less weight is borne on the opposite leg. The feet are constantly engaged in braking and are also slightly raised towards the back. The poles are not brought in front of the body. On downhill stretched the pole thrust is slightly less powerful than when walking on level or inclining terrain (picture 5).

Picture 5

2.12. Training of Nordic Walking Technique

Training of Nordic walking technique is basically simple and can be learned from one or two lessons. The movement of arms is the same like in cross country skiing. For person who already knows that style it is easy to learn Nordic walking properly. On begging on learning every new skill it would be good to used all methodic preparation, because of good felling and safety. The person who is learning technique, first of all must to know right posture of the body during Nordic walking. The second think is to learn how to change positions of the body.

First step would be exercise of using alternating movements of legs and hands, took a pole and try to walking with normal speed. Upper limbs should be relaxed, backwards and forwards in shoulder joint. After that we are doing the same thing faster concentrated on the same movements. Muscles of neck and shoulder should be relaxed. Next thing which should be done is extension of steps. First heel touches the ground, and then body weight is going on the whole foot. After that the heel leaves ground first, and then first part of the foot and the end toes.

In this part can became problem in coordination between movements of arms and legs. Than can be manifested as robotically walking, not synchronized walking, movements of arms can be faster then movements of legs. If we are notice that mistakes, we should do exercises slowly. When a technique is good we can do exercise faster. Exercising of technique can improve walking technique an prepare person for walking with poles (**Vystrčil, 2005**)

The second step is took the poles in hands. For beginning the poles are hanging free in the hands. We are focused on walking with relaxed muscles of neck and shoulders. Upper limbs are free and they are moving in direction forwards and backwards near to the body (**Vystrčil, 2005**).

The last step should be using the poles during the walking. We are putting hand rail between thumb and index finger, and we are trying to find a rhythm of walking. Objective point should be including maximally strength of upper limbs.

We should pay attention on some important things

- Longer stride then in ordinary walking
- Small forward of the body
- Use all foot from hells to toes
- Keep poles thrust behind the line of your pelvis
- View should be 20 m in front of the body

2.12.1. Possible Mistakes in the Nordic Walking Technique

Some people can have problem with learning Nordic walking technique. Some mistakes can has positive influence but most of them could produce injures.

- Disorder of coordination between upper and down limbs
- Irregular posture of the body
- Wrong holding of the poles
- No repercussion from the poles with hands
- Incorrectly used straps
- Hands so close or far away from the body
- Too long steps
- Too high poles
- Unconformity shoes
- Defaults of worming up exercise and stretching exercises
- Walking with poles but with out using them

2.13. Types of Nordic Walking

Depends of physical activity, motor abilities and skills and healthy of the persons we can define three different levels.

Recreation group

In this level are people which have some limitation in physical disposition, or they do not have so much experience with properly exercise, has lower level of coordination abilities or has some healthy obstacle but they can use poles with out any problems.

In recreational level are mostly people which are looking for good and effective physical activity for their free time, and they can do that independently of their ages. Also it is good for people who want to change their life style and become oriented on healthy physical activity (**Mira 2008**).

Conditioned group

This level is for people which already have some physical experience, doing some sports activities (couples days per week) and already knows their abilities and limits. Have strongest muscles but their flexibility can be lower, what can limit range of the movements and produce some problems in balance.

On this level are people who want to improve their physical conditions, and use Nordic walking as supplement activity to some others physical activities (**Mira 2008**).

Active group

In this group are usually athletes which already knows what they should expect form the training. They are in excellent condition, with very good range of movement, and with good flexibility. Coordination and balance of them are on high level.

From them we are expecting to like to work in group or individually, understand explanation of the movement without needing principles of movement (**Mira 2008**).

2.14. Equipment for Nordic Walking

As any other sport, for Nordic walking we have special equipment. Basic equipment for Nordic walking is special kind of poles. Inadequately poles and wrong techniques can produce some defects and lost interesting on physical activity for a long time. From that reason is important, during the construction of the poles, to know all specifics of activity (**Vystrčil, 2005**).

For doing Nordic walking three things are important:

- Poles – high of the pole should be 0.68 of high of the body. If we are holding a pole vertically the angle in elbow should be 90 degrees. Instructor of Nordic walking should be able to choose poles and set them.
- Sports shoes – should be comfortable and quality. Special shoes (Balance-Step), with special shape of sole, which helps to have good posture of the body, are recommended.
- Clothes – shod by sports, comfortable that person can move without any problems

2.14.1. Poles for Nordic Walking

Pole for Nordic walking should be, first of all, safety (picture 6). Hand rail should be from special materials for easiest holding and longer using. If is hand rail produced as should be, there will be no vibrations which are pass on the hands, elbow and shoulder (**Vystrčil 2005**).

Picture 6

Nordic walking poles are different from walking and trekking poles. Poles for Nordic Walking are lighter weight and have a special strap (picture 7). Often Nordic Waking has an egomaniacally shaped handle, and specific for left and right hand. Strap should be heavy, soft, simple and shaped. Dimension of strap depends on dimension of palm, and should enable maximal spread of movement.

Picture 7

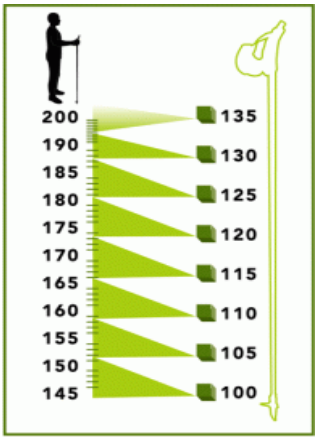
Dimension of poles body depends on stroke and pressure on them not just during the walking, also during some exercise which are connected with Nordic Walking (picture 8). Body of the poles has to be heavy but flexible, that can be used on different type of surface.

Picture 8

Also the important things fore poles is their weight. During the walking we should not feel weight of the poles. A good quality of pole will have an element of carbon in their composition. That affects weight, power transfer and the shock absorbency. Good poles should have at least 40% of carbon content.

Poles made for fitness walking have a „paw“, made for walking on asphalt, set at the proper angle to hit the pavement. Other one uses a rubber tip similar to cane to, which wears unevenly.

The simplest and easier way to choose properly high of poles is to put pole in vertical position and hold it. The angle in elbow should be 90 degrees. Someone who have more experience with Nordic Walking, or is in bigger fitness level, can use poles longer for couple centimeters. The second way how to measure high of poles is to from high of person deduct 50 centimeters. On beginning is better to use shorter poles. That will help to learn Nordic Walking technique properly (picture 9).



Today we have a lot of kinds of poles for Nordic Walking, form simplest and cheapest for beginners to high quality for athletes. The most famous brands for Nordic Walking poles are: LEKI, SWIX, GABEL, BIRKI, and EXEL.

Picture 9

2.15. Physiology of Nordic Walking

Nordic Walking is walking combined with the arm technique using poles. Pressing into the ground with the poles supports motion and intensifies the exercise of the chest, shoulder an arm muscle. Because of that physical load and the calorie consumption during Nordic walking is 20 to 50 percent higher then during normal walking.

Using of poles significantly increasing oxygen uptake, heart rate and energy expenditure by approximately 20% compared to walking with out poles.

1. **Porcari, J.P** et al. 1997

The study was measure increase intensity of exercises and energy expenditure during walking with poles. In that research was included 32 people, 16 women and 15 men in the age range from 19 till 32 years. All of them did the test „vita maxima" and two sub maximal tests (one walking with poles and second walking with out them). Measurement was on treadmill 20 min, during the different days. They did the tests on same speed. Heart rate and VO_2max were measured every minute.

It was found that during the walking with poles VO_2max was around 23% higher (4.4 ml/kg/min), energy expenditure was 22% higher (1.5 kcal.min) and heart rate around 16% higher (18bpm). There were not separated results for woman and men.

2. **Chruch T.S, Earnest C.P, Morss G.M 2002**

The aim of studies was comparing the physiological responses (oxygen consumptions and energy expenditure) of Nordic walking to regular walking under field testing conditions. Eleven women (M age = 27.1 years) and eleven men (M are = 33.8 years) walked 1.600 m with and without walking poles on a level, 200m track.

For woman Nordic Walking results in increased oxygen consumption for 3.0ml/kg/min, caloric expenditure for 0.9 kcal/min and heart rate 9 bpm more then in regular walking. Results for men were in oxygen consumption 2.7 ml/kg/min, caloric expenditure 1.2 kcal/min and heart rate 8.2 bpm more then in regularly walking.

More authors in their researches improved physiological indicators for Nordic walking for women and men. Nordic walking increasing aerobic capacity, endurance of

muscles, works down all defects on neck and shoulders and has positive influence on psychical attitude. With control of heart rate we can control intensity of load and with those better results.

2.15.1. Oxygen consumption

Physical working capacity or physical fitness is functional ability of organism to increase level of metabolism according to exigency of the physical activity. Metabolism in this case means transformation of chemical energy in mechanical energy, precisely, contraction of muscles.

Whereas that energy potential of human organism is for sure the most important factor which defined limit of physical activity, on the same way doing sports permits identification physical ability with level of energy capability.

Term „aerobic capability" defined scope of aerobics process of metabolism of human body and represent bigger part of totally energy capability of human benign. In differences of that, term „maximal oxygen consumption" or „maximal aerobic power", means intensity of aerobic process and represents ability of organism in one period to spend maximum of oxygen. Because of correlation, these two terms are mostly identified, so VO2 max is usually accepted as indicator of aerobic capability, and in the same time like best indicator for level of physical activity human being.

VO_2max is express in liters in one minute (l/min) or in relative relation milliliter in one kilogram in one minute (ml/kg/min). This second way is often because of the compurgation in endurance and strength of athletes.

2.15.2. Measurement of VO2 max

Measurement of VO_2max is operated with load test, where load and intensity of exercising progressively increasing on treadmill or bicycle ergo meter, on the same time is measured concentration of the inspired oxygen and expired carbon dioxide. Inspire and expire are measured with special equipment and during the test person has mask on his

face. VO_2max is reached when in VO_2max VO2 stays in a same level even is load still increased.

Estimation of VO_2max can be:

VO_2max = Q (CaO2 – CvO2)

Q – Cardiac output

CaCO2 – arterial oxygen content

CvCO2 – venous oxygen content

Another estimate of VO_2max is

VO_2max = 15 x HRmax / HRrest

HRmax – maximum heart rate

HRrest – resting heart rate

Cooper test

VO_2max = (d12 – 505) / 45

d12 – distance in meters covered in 12 minutes

2.15.3. Average values

Absolute value of VO_2max is 40 – 60% bigger in men then women. Average younger untrained man would have VO2max approximately 3.5 l/min, or 45 ml/kg/min. Average untrained women would have VO_2max around 2.0 l/min, or 38 ml/kg/min. These values can be much more increased with training, depends of the person. Condition and VO_2max decrease with aging.

In endurance sports activities VO_2max is most important thing. High level competitors have VO_2max from 75 – 95 ml/kg/min. Marathon runners have VO_2max around 70 ml/kg/min.

3. AIMS AND OBJECTIVES

3.1. Aims

To compare metabolic (express in % VO_2max) and cardiovascular (express in % MHRR) load during Nordic and Ordinary walking.

3.2. Objectives

- Analyze impact of speed and slope on metabolic and cardiovascular load during Nordic Walking.
- Analyze impact of speed and slope on metabolic and cardiovascular load during Ordinary Walking.

3.3. Research questions

- What is the difference in metabolic and cardiovascular load during Nordic and Ordinary Walking?
- What impact has the movement speed and slope on metabolic and cardiovascular load during Nordic and Ordinary walking?

4. METHODS

Characteristic of tested group

Tested group considered 10 students and employers of Faculty of Physical Culture, Palacky University in Olomouc. Average age was 26.9 ±3.5 year, BMI 23.7±2.2 $kg \cdot m^{-2}$, maximal oxygen consumption (VO_2max) 56± 8 $ml \cdot kg^{-1} \cdot min^{-1}$.

Conditions for measurement were standard, in laboratory. Temperature was from 20 till 24 degrees, humidity from 40 till 60%. All candidates were introduced what kind of test they will do and with process of the test. Also all candidates were healthy. Candidates were not use alcohol last 24 hours and smoking cigarettes last 12 hours before test, and they did not have meal al least 2 hours before test.

All volunteers are accepted all realization of the test, and they confirm that with their signature.

Basic statistic characteristics of test are in table no. 1.

Table 1.

Parameter		All (n=10)
age [years]	M SD min/max	26,90 3,51 24/33
weight [kg]	M SD min/max	78,07 6,66 66,16/87,04
high [cm]	M SD min/max	180,60 3,20 175/186
BMI [$kg \cdot m^{-2}$]	M SD min/max	23,96 2,22 20,19/26,91
VO_2max [$ml \cdot kg^{-1} \cdot min^{-1}$]	M SD min/max	56,00 7,98 44,1/68,6

Description: M – arithmetic mean (average), SD – Standard deviation, BMI – Body Mass Index, VO_2max – maximal oxygen consumption.

4.1. Methodology of data collections

Gradually to the maximum of the test

All volunteers were doing the same test gradually to the maximum on treadmill for Nordic Walking LODE Valiant (Netherland). Analysis of breathing gas was measure with analyzer ZAN Ergo USB 600 (Germany). Heart rate was measure with belt on the chest Polar T 31 (Finland) and with receiver transfer to the PC.

Test begin in wormed organism which is in fifth minute with speed of 8 $km \cdot h^{-1}$. On the firs 4 minutes slope is 0% and during fifth minute increase on 5%. During next minute of the test, speed is increase till 10 $km \cdot h^{-1}$, slope does not change. After that individual test is beginning, where every minute speed increase for 1 $km \cdot h^{-1}$. In moment when speed increase till 15 $km \cdot h^{-1}$ slope starts to increase every minute for 5%. Test is finished when organisms is exhausted, when volunteer are not able to overcome intensity.

Obtained values were oxygen consumption VO_{2max}) [$ml \cdot kg^{-1} \cdot min^{-1}$], and directly measuring of heart rate (HR_{max}). Details which were calculated are the weight of volunteers, speed and slope of treadmill, with equation.

$$W = (weight \cdot (2.2 + speed \cdot (2.11 + 0.25 \cdot slope)) - 151) / 10.5),$$

This is part of the software cross-country treadmill.

4.2. The value of the maximum reserve of heart rate (MHRR)

MHRR is difference between heart rate HR_{max} and heart rate before exercising in rest HR_{rest} ($MHRR = HR_{max} - HR_{rest}$). Heart rate in rest was measure in the morning after waking up of volunteer without any physical exercise before that, minimum 24 hours before testing. HR_{max} was measure during the maximum of the test.

4.3. Realization of the test

Before measurement all volunteers were practicing Nordic Walking technique with instructors to ensure correct technique of Nordic Walking during measurement.

Measurement of Nordic Walking was on 3 slopes (0%, 5%, and 7.5%) and with four speeds (6.0 $km \cdot h^{-1}$, 6.6 $km \cdot h^{-1}$, 7.2 $km \cdot h^{-1}$ a 7.8 $km \cdot h^{-1}$). According to that there are twelve tests. All tests are done on the same treadmill LODE Valiant (Netherland).

All tests were around 15 min. First five minutes were for worming up and preparing organism for 10 minutes of measurement when we got all necessary results.

In analysis of breath gas we were using ZEN Ergo USB 600 (Germany). Cheats belt Polar T 31 was used for measurement of heart rate, and with Polar receiver transferred to the PC.

All results which we got we put in the table in Microsoft Excel that we could work on them after that.

4.4. Training of Nordic Walking technique

As we mentioned before, all volunteers are learned correct Nordic Walking technique with instructor of Nordic Walking. Correct technique is most important thing. Without correct technique would be impaired physiological response of the organism. Because of that practicing of the technique with instructor took a lot of time.

Technique of Nordic Walking is not so hard to learn, because arise from Ordinary Walking Technique. Experience from classic skiing could make practicing easier. Technique of Nordic Walking is possible to learn in two blocks of training, especially with a helping of instructor of Nordic Walking, but adoption and automatics of technique will take more time.

During the Nordic Walking trunk of the body is little bit forward, head is in continuation with spine, and view is straight. Back are straight, shoulders are little bit back and pulled down. We should try to keep our chest relaxed so that the movement in on the upper extremity in the shoulder joint could do not have bad affect on some unused muscles. There is a contra lateral rotation of the upper and lower extremity. The movement starts in the upper body extremities, the elbow is drawn, then moves smoothly forward and upward with gradual bending of the elbow up to support of the poles. Important is that reflection from the poles was making in the final part of tapping, when palm is open and upper extremity is stretches. Step rate depends of the speed of walking. Slower speed smaller steps and opposite. Reflection is beginning from the front part of the foot and toes. All movement in Nordic Walking, with reflection and feet tapping on the opposite side or the body at the same time, is “cross walking”. After completion of the all cycle we are repeating the same thing (**Sovova, 2008; Mira, 2009**).

4.5. Realization of the test of the Ordinary Walking

Test of the Ordinary Walking we did on the same way as we did test of Nordic Walking. Combination of the slop was (0%, 5% and 7,5%) and combination of the speed was (6,0 km · h^{-1}, 6.6 km · h^{-1}, 7.2 km · h^{-1} a 7.8 km · h^{-1}), that mea. twelve tests. All tests we did on the treadmill LODE Valiant (Netherland).

Every test takes fifteen minutes. First five minutes was or worming up and preparing for test, and another 10 min we did testing of values.

For analysis of the breath gases we used analyst ZAN Ergo USB 600 (Germany). Chest Belt Polar T 31 we used for measurement of the heart rate, and we used Polar receiver to forward data on the PC.

4.6. Processing of data

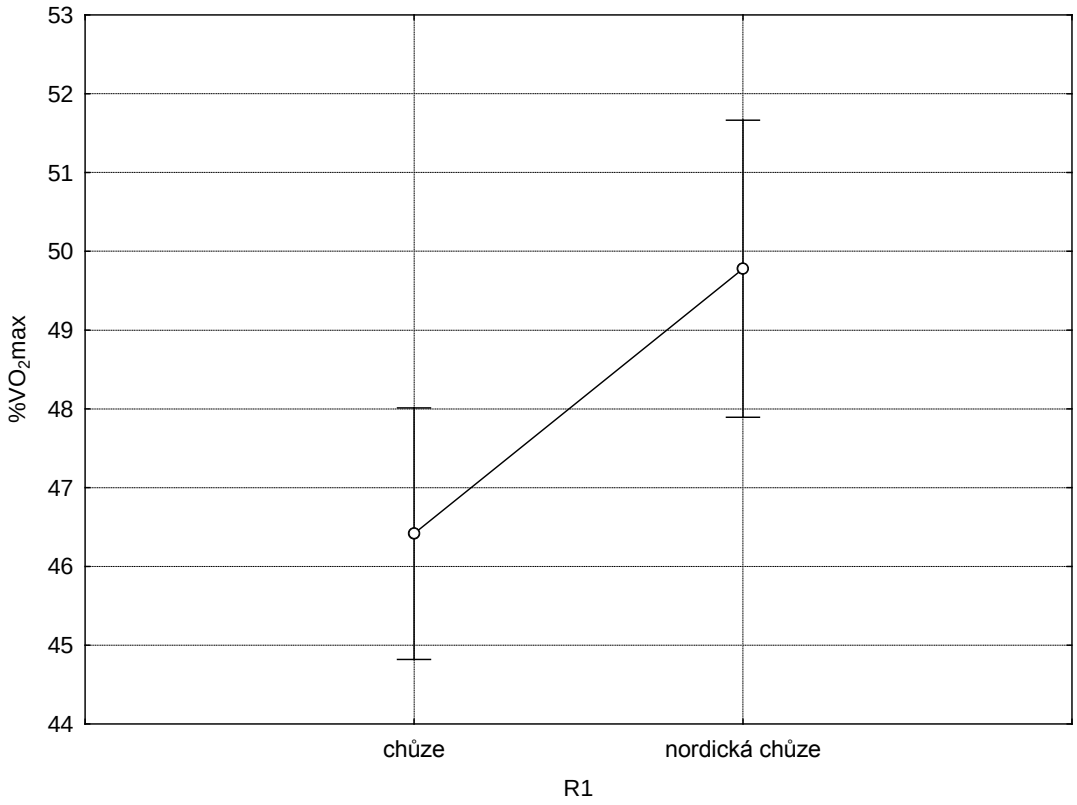
Measured values, oxygen consumption, heart rate we convert on the % of VO2max and % of MHR were measured average for 1. – 5. minutes, and from 6. – 10. min we measures every minute independently (appendix 1). The values we got were averaged for each speed and slope. The result is average of percents of VO_{2max} and presents of MHR for each speed and slope. For determining of variations we used standard deviation. Data processing we did in Microsoft Excel 2003. The statistical data processing we used the Software Stastistica 8.0.

To compare the dependent between variables we used ANOVA for repeated measurements. The significance level we determined on the levels of 0.05, 0.01 and 0.001.

5. RESULTS

5.1. Comparison of Oxygen Consumption

Average intensity in the test, expressed on the percents of maximal Oxygen Consumption, if we are ignore speed and slope, all volunteers was during the Ordinary Walking 46,4 % VO_2max (SD=13,7) and during the Nordic Walking 49,8 % VO_2max (SD=14,8). Intensity of load during Nordic Walking was significantly higher (p = 0.000) than in Ordinary Walking for 3.4% VO_2max. Picture 10.



Picture 10 Oxygen Consumption during Ordinary (chůze) and Nordic Walking (nordická chůze) (average values of all monitored segments) (n = 10).

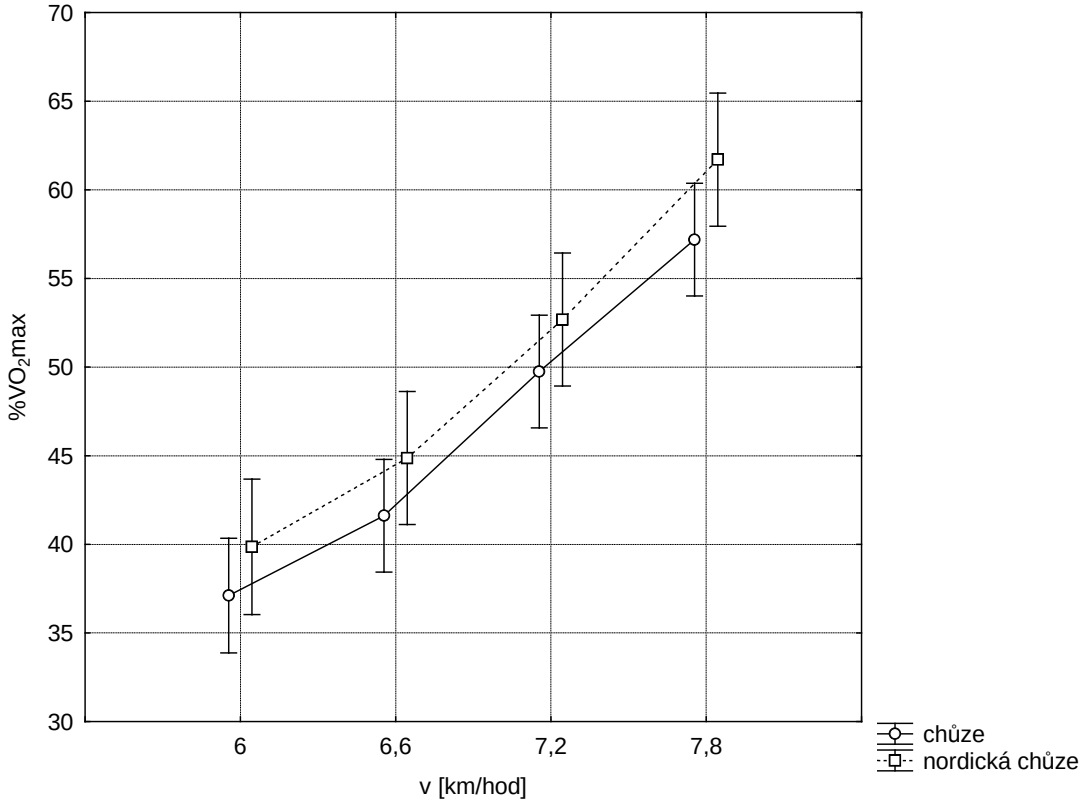
Comparison of average values of oxygen consumption of all test subjects with all variants of speed and slope are shown in Table 2. The difference between Nordic Walking and Ordinary Walking we can see that for all part of the test oxygen consumption during the Nordic Walking is higher. Statistically significant levels of oxygen in Nordic Walking comparing to the Ordinary Walking is found during speed of 6,6 $km \cdot h^{-1}$ and 7,8 $km \cdot h^{-1}$. Values close to statistical significance are at the speed of 6 $km \cdot h^{-1}$ and slope of 5%, then at the speed 7.2 $km \cdot h^{-1}$ and slope 7.5% and at the top of speed 7.8 $km \cdot h^{-1}$ and in biggest slope 7.5%.

Table 2. Average value of oxygen consumption of the all various of speed and slope.

%VO2max							
Speed	slope	OW		NW		NW-OW	p
km/h	%	M	SD	M	SD	differences	
6	0	29,77	1,20	31,15	1,20	1,38	0,521
6	5	38,95	1,12	42,57	1,32	3,62	0,093
6	7,5	42,61	1,30	45,91	1,39	3,30	0,153
6,6	0	32,14	1,36	36,85	1,48	4,71	0,029
6,6	5	43,45	1,18	46,05	1,26	2,59	0,228
6,6	7,5	49,25	1,26	51,71	1,37	2,47	0,252
7,2	0	38,72	1,39	41,47	1,51	2,75	0,202
7,2	5	51,94	1,33	54,38	1,33	2,44	0,256
7,2	7,5	58,60	1,38	62,21	1,75	3,61	0,095
7,8	0	45,85	1,43	52,06	1,63	6,21	0,005
7,8	5	58,77	1,56	62,07	1,48	3,31	0,126
7,8	7,5	66,95	1,76	70,98	1,53	4,02	0,063

Legend: M – arithmetic average, SD – standard deviation, OR – Ordinary Walking, NW – Nordic Walking, %VO2max – percent of maximal oxygen consumption, p – level of statistically significant difference ($p \leq 0,05$), (LSD test).

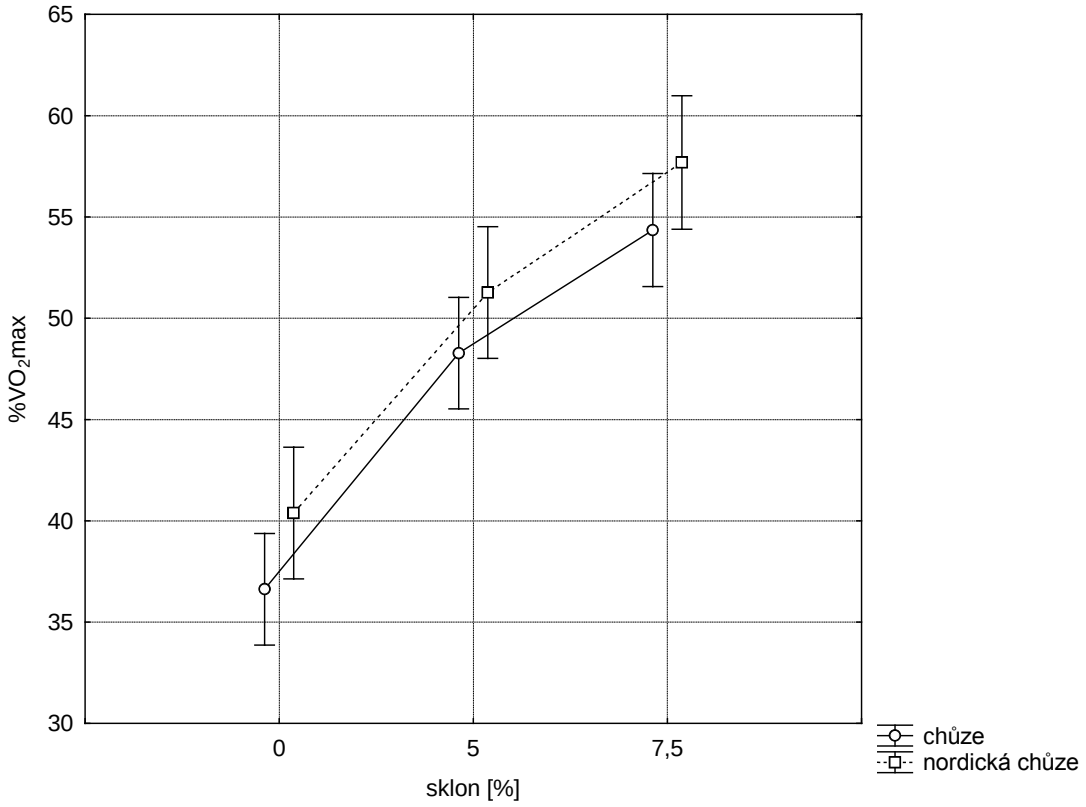
Comparison of the oxygen consumption in different speed and on the same slope always showed higher values in Nordic Walking then during Ordinary Walking. That increase was 1.4 % during speed of 6 $km \cdot h^{-1}$, 4.7 % during speed of 6.6 $km \cdot h^{-1}$, 2.7 % during speed of 7.2 $km \cdot h^{-1}$, and 6.2 % during speed of 7.8 $km \cdot h^{-1}$ (picture 11). All these differences we compared using LSD tests are statistically significant (Annex 2).



Legend:: % VO_2max – percent ox maximum oxygen conception, v – speed.

Picture no. 11 Comparing oxygen consumption during the Ordinary and Nordic walking on the same slope but different speed.

When we compare oxygen consumption in the same speed but in different slope, we got results that Oxygen consumption increased during Nordic Walking comparing to Ordinary Walking. That increase was 3.8 % in slope of 0 %, 3 % in slope of 5 and 7.5% (Picture 12). All these differences we compared using LSD tests are statistically significant (Annex 3).

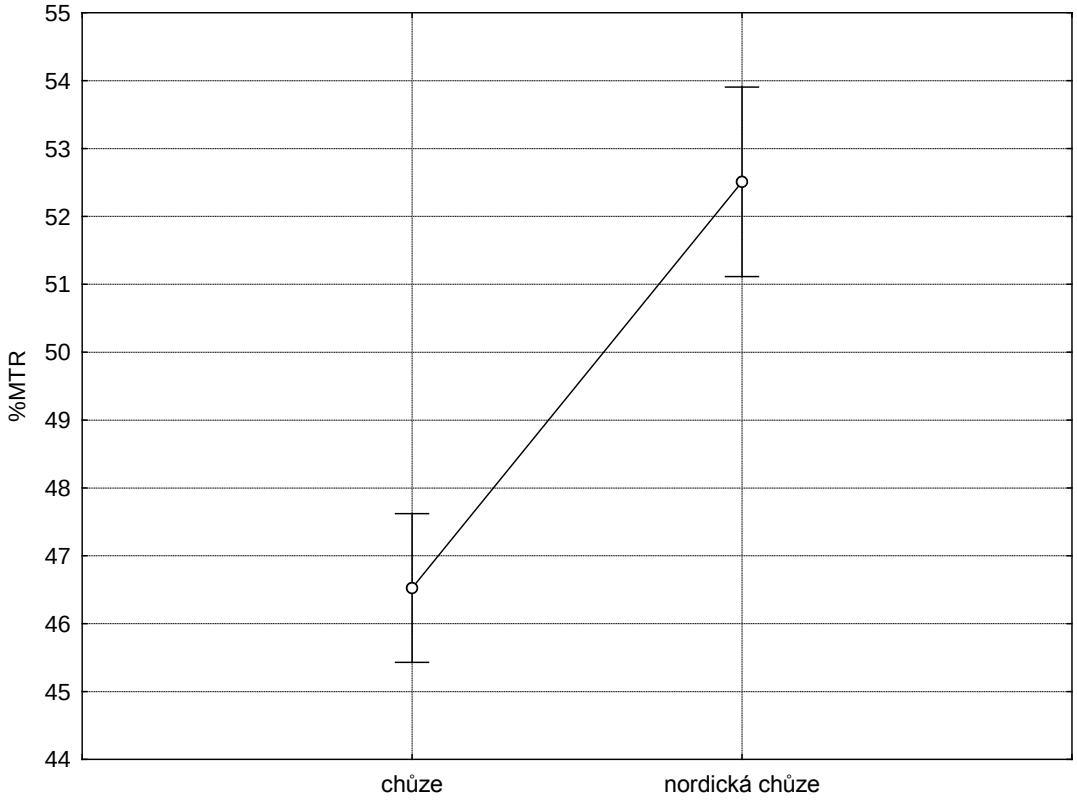


Legend: % VO_2max – percent of maximal oxygen consumption

Picture 12 Comparative of oxygen consumption between Nordic and Ordinary walking with same speed but with different slope.

5.2. Comparison of percents maximal reserve of heart rate (% MHRR)

During Nordic Walking was statistically significant increase of the heart rate for 5.9 % of MHR (Picture 13). Average value of the heart rate in percents of MHRR, all measured sections, regardless on the speed and slope, in all volunteers during Nordic Walking was 52.5 % (SD = 14); During Ordinary Walking value was 46.6 % (SD = 13.1).



Legend: MHRR (MTR) – maximal heart rate reserve

Picture 13 Heart rate in % during Ordinary and Nordic Walking regardless on the speed and slope (average value all measured sections) (n = 10).

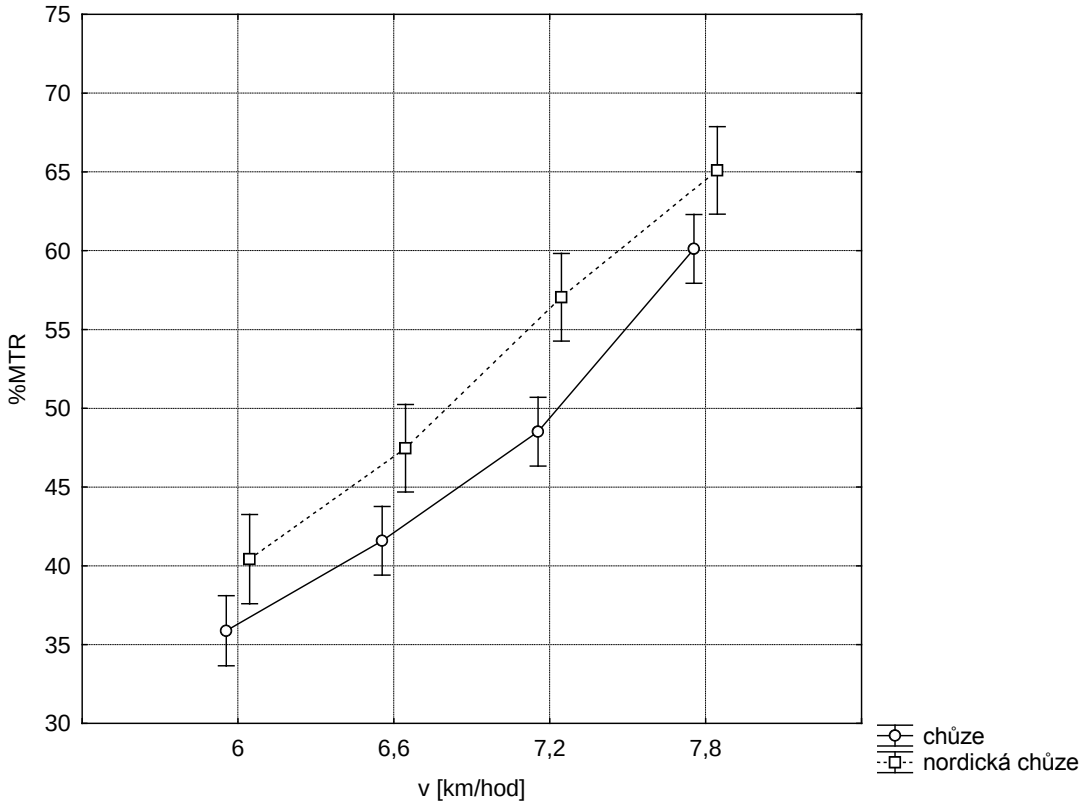
Comparison of the average hart rate expressed in percents of all volunteers of all versions of speed and slope we can see in Table 3. This table showing us, that in all loads of intensity heart rate was increase during Nordic Walking. Statistically significant of increase of heart rate in Nordic Walking in comparison on Ordinary Walking in speed 6 $km \cdot h^{-1}$ slope 5 %, in speed 6.6 $km \cdot h^{-1}$ and slope of 7.5 %, speed 7.2 $km \cdot h^{-1}$ on each slope (0 %, 5 %, 7.5 %); speed 7.8 $km \cdot h^{-1}$ on slope 0 and 5 %. The bigger difference is between Ordinary and Nordic Walking during speed of 7.2 $km \cdot h^{-1}$ on flat where is difference 11.2 % MHRR.

%MHRR							
Speed	slope	OW		NW		NW-OW	p
km/h	%	M	SD	M	SD	difference	
6	0	29,37	1,28	33,93	1,24	4,57	0,067
6	5	37,31	1,43	42,54	1,65	5,23	0,036
6	7,5	40,97	1,42	44,50	1,71	3,53	0,142
6,6	0	33,83	1,35	40,25	1,56	6,43	0,011
6,6	5	42,86	1,21	47,41	1,47	4,56	0,068
6,6	7,5	48,08	1,27	54,73	1,85	6,65	0,008
7,2	0	37,25	1,35	48,46	1,83	11,21	0,000
7,2	5	51,75	2,03	59,75	2,01	8,00	0,002
7,2	7,5	56,56	1,81	62,93	2,30	6,38	0,011
7,8	0	47,97	1,45	53,52	2,14	5,55	0,026
7,8	5	61,20	2,31	66,66	2,41	5,46	0,029
7,8	7,5	71,18	2,30	75,11	2,80	3,94	0,114

Legend: M - arithmetic average, SD – standard deviation, OW – Ordinary Walking, NW – Nordic Walking, MHRR – maximal reserve of the heart rate, p – level of statistical significance, (LSD test).

Table 3 Average value of Heart rate during different speed and slope.

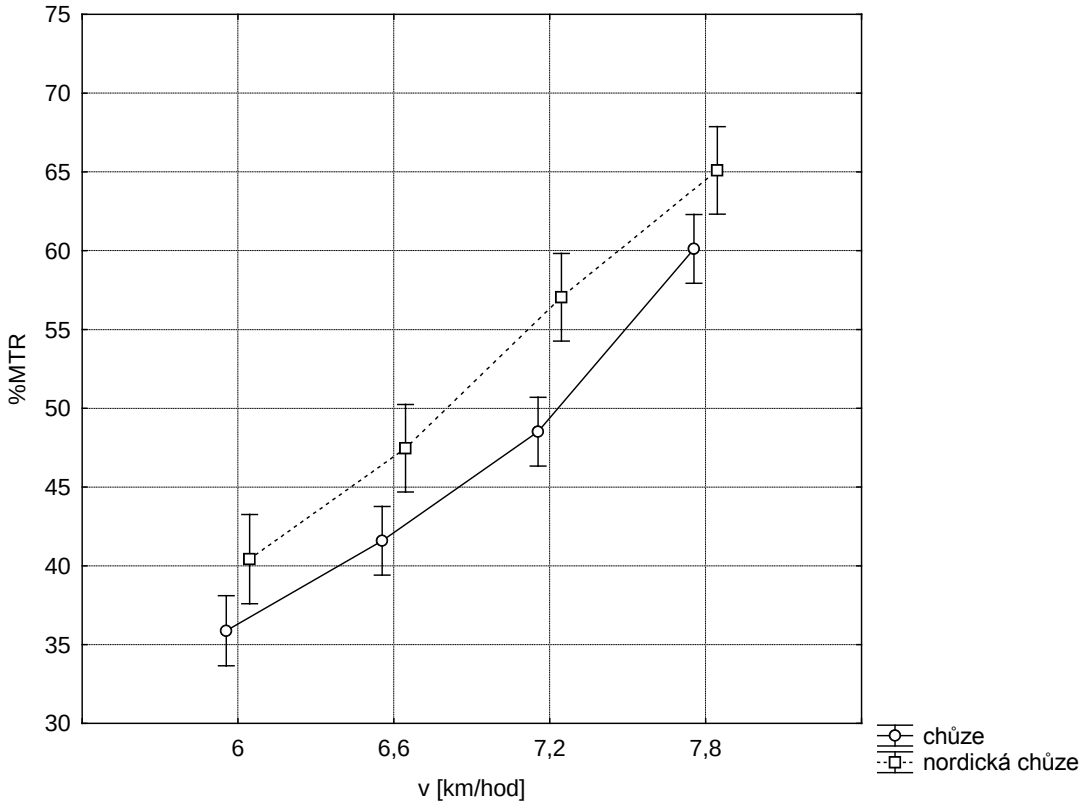
The comparison showed that the heart rate expressed in % of the MHRR at each speed regardless of the slope was always higher in Nordic Walking. That increase amounted 4.6 % during speed of 6 $km \cdot h^{-1}$, 6.4 % during speed 6.6 $km \cdot h^{-1}$, 11.2 % during speed 7.2 $km \cdot h^{-1}$ and 5.6 % during speed 7.8 $km \cdot h^{-1}$ (Picture 14). All there differences which are compared using LSD test are statistically significant.



Legend: MHRR (MTR) – maximal reserve of heart rate, v – speed.

Picture 14 Comparison of heart rate expressed in % MHRR, during Ordinary and Nordic walking in all speeds regardless of slope.

Comparison in different slopes regardless on the speed showed that of the heart rate expressed in % MHRR is higher in Nordic Walking then in the Ordinary Walking. The increase amount 8.3 % on field, 6.2 % on slope of 5 % and 3.9 % in slope 7.5 % (Picture 15). All these differences are compared using LSD test are statistically significant.



Legend: MHRR (MTR) - Maximal reserve of heart rate

Picture 15 Comparison of heart rate expressed in % MHRR during Ordinary and Nordic walking, in different slopes regardless on the speed.

6. DISCUSSION

All test of Ordinary and Nordic Walking are done in laboratory of Physiology on Faculty of Physical Education. That laboratory offers the same conditions for all measurements and volunteers. All tests were controlled from head person who was trying to eliminate all possible mistakes in technique, especially in Nordic Walking. We tried as much as we could to have standard conditions during measurements that we would not have mistakes in results. In the test were included ten volunteers.

Main goal of this work is comparison of metabolic (expressed in % of VO_2max) and cardiovascular (expressed in % MHRR) load during Ordinary and Nordic Walking. Results showed when we compared all measured sections we got a statistically significant increase during Nordic Walking in oxygen consumption for 3.4% more then during Ordinary Walking. Cardiovascular load was also statistically significant increased during Nordic Walking for 5.9% of MHRR. Reason of that increase we can explain on that way that during Nordic Walking including larger amount of muscles like muscles of shoulder girdle and upper back.

When we are comparing heart rate, we got bigger increase during Nordic Walking then in oxygen consumption. Reason can be according to Hamar and Lipkova (2001) level of activated muscles group and their ability to extract oxygen from blood. For example, during running more muscles are included, that is shows better extraction of oxygen, and that means lower heart rate. During strength exercise that ratio is even higher, where is for low level of oxygen consumption reaches a higher level of heart rate. During Nordic Walking strength exercises are in muscles of upper limbs, and because of that there is not so big increase of oxygen consumption then in heart rate. Other reasons why is, during Nordic Walking, difference in heart rate bigger then differences in oxygen consumption, can be involving in the work upper body which causing intra thoracic pressure. That pressure reducing systolic volume, and to maintain the total cardiac output, heart rate must be increased. Hamar and Lipkova (2001) cites that during intensity 40 to 50 % maximal oxygen consumption reaches its maximum of systolic volume, so that means that further increase of minute volume is ultimate only with increase of the heart rate.

In first research question, we were wondering about the difference between metabolic and cardiovascular load during Nordic and Ordinary Walking. Results are showing us that during the Nordic Walking we always have bigger oxygen consumption and increasing heart rate then in Ordinary Walking no matter on speed and slope. That is confirmed also by researches Church (2002), Pocari (1997) and Rodgers (1995), and their results were showing us increase of oxygen consumption and heart rate compared to the Ordinary Walking. If we are focusing on the absolute value of oxygen consumption and converts it to the energy expenditure we found that consumption is during Nordic Walking 0.136 $kcal \cdot kg^{-1} \cdot min^{-1}$ and during Ordinary Walking 0.127 $kcal \cdot kg^{-1} \cdot min^{-1}$. We can compare that results with values which indicated Hamar and Lipková (2001), which during Ordinary Walking indicated energy consumption 0.080 $kcal \cdot kg^{-1} \cdot min^{-1}$. Significant difference between our and results of Hamar and Lipková, can be different speed of walking or slope, were already mentioned authors observed energy expenditure. Unfortunately that is no listed in their edition. In our research we are counting with average of all speeds and slopes. During speed of 8 $km \cdot h^{-1}$ Hamar and Lipková (2001) cite consumption 0.147 $kcal \cdot kg^{-1} \cdot min^{-1}$ what is very close to our results of consumption during Nordic Walking. Explanation is bigger amount of involved muscles and average got from all speeds (6 – 7.8 $km \cdot h^{-1}$) and slopes (0%; 5%, 7.5%).

Second research question is what kind of influence has speed of movements ad slope on the metabolic and cardiovascular load during Nordic and Ordinary Walking in different levels of intensity (Table 3). In all cases when we are comparing Ordinary and Nordic Walking we got increasing of oxygen consumption in Nordic Walking. Explanation can be that during Nordic Walking we are using more muscles then in Ordinary Walking, because of using poles where we have increase in oxygen consumption. Máček a Máčková (1997) cites that energy expenditure during walking depends of weight of person, clothes, loading, speed of walking, type of surface and incline. With increasing of speed and weight, energy expenditure is rising. Also with a bigger slope energy expenditure can increase up to 25 % more then in flat. It can be considered that during Ordinary Walking with a bigger slope energy expenditure will increase, and during walking and using poles in the same time, energy expenditure will be even bigger, because of using more muscles. Parrey and Fabre (2008) did research on

three slopes (flat, uphill, downhill) with slopes of 15 % and got conclusion that during the walking with poles metabolic load are increased, especially in downhill walking and that using poles was not affect on cardiovascular load. That is in contrariety with our results, were we got increase in metabolic and cardiovascular load in bigger slope during Nordic Walking against to Ordinary Walking. Máček a Máčková (1997) are also mentions that on lower speed energy expenditure during walking is lower then during running on the same speed, and opposite, on higher speed energy expenditure is higher during walking then during running. They said also that on speed 7 till 8 $km \cdot h^{-1}$ is the same oxygen consumption. Because we used in this research speed range from 5 - 7,8 $km \cdot h^{-1}$ we can say that we can achieve the same oxygen consumption during walking and running, but in Nordic Walking oxygen consumption will be higher and we will have less damaging joints than in running. Impact of speed on oxygen consumption analyzed Church (2002) who indicates the differences in oxygen consumption in Porcari (1997), Rogers (1995). He explained that in Rogers research there was no so big oxygen consumption as in research of Porcari because they used so high speed and all volunteers could not use poles effective.

If we are look in results of cardiovascular load in different versions of speed and slope, we found that when we were used poles in all intensities we got increase in heart rate (% MHRR) (Table 4). Statistical significance of the increasing in heart rate expressed in % MHRR is found in eight cases, combinations of speed and slope, while for oxygen consumption we did only in two cases. As we mentioned before, the reasons can be strength exercise during hands movements, which are insufficient supply of oxygen or in insufficient conditions for the heart work. If we summarizing our results we can see that there is increase metabolic and cardiovascular load with higher speed and bigger slope in Nordic and Ordinary Walking. Nordic Walking was in all cases of intensity, higher then Ordinary Walking.

Perception of effort is objectively impossible to measure precisely. Perceived effort values are influenced by the condition of volunteer (stress, tiredness, psyche, illness etc.). Tests were doing in couple days which can affect on results and also small number of volunteers (10). Because of that this data will be used in farther research, with bigger number of volunteers.

Nordic Walking is more appropriate physical activity than Ordinary Walking. Using poles leads to increase of energy expenditure even if we are not increasing speed or slope. Loading of organism is split out to the bigger number group of muscles, and on that way overloading of the muscles is eliminated.

Testing was in laboratory in the same conditions of speed and slopes. We can only guess how would look result if we did them outside. There are not so much researches of the Nordic Walking who are done outside.

Results of this research could be limited on way how we choose and with the numbers of volunteers. Testing was not creates randomly but was based on voluntariness.

7. CONCLUSION

In this study we managed to reach main goal and other goals and to answer on our research questions.

Main goal of this work was comparison of metabolic (expressed in % of VO_2max) and cardiovascular (expressed in % MHRR) load during Ordinary and Nordic Walking. Results showed when we compared all measured sections we got a statistically significant increase during Nordic Walking in oxygen consumption for 3.4% more then during Ordinary Walking.

Cardiovascular load showed us that using of the poles during the walking in all measurements no matter on speed and slope will increase heart rate for 5.9 % of MHRR compared to walking without poles. This difference is statistically significant. During Nordic Walking we got results of measurement that increasing of cardiovascular load (5.9 %) is bigger then metabolic load (3.4 %). This difference we can explain on that way that in Nordic Walking we are including upper parts of the body, larger amount of muscles like muscles of shoulder girdle and upper back, and that is make worse conditions for normal heart work. Reason is smaller systolic volume, and that is follows increase of the heart rate.

When we evaluate impact of speed and slope on metabolic and cardiovascular load during Ordinary Walking, we will get conclusion that in all sections we got increase in oxygen consumption and heart rate. During Nordic Walking that increasing is even bigger.

Nordic Walking significantly increases energy expenditure then in ordinary Walking. We can recommend Nordic Walking as an appropriate physical activity, which can be perfect for all growing diseases of civilization.

8. SUMMARY

Nordic Walking is relative young physical activity and one of the fastest growing exercise activities in the world. Nordic Walking is actually normal walking with using of special poles what is including larger numbers of muscles than in Ordinary Walking. The main goal of this thesis was to investigate and compare metabolic and cardiovascular during Nordic and Ordinary Walking, with indicators as oxygen consumptions and heart rate. The long term perspective of this work, which is part of bigger research, is to obtain important information about physical activity and their impact on the organism.

The main goal was to compare metabolic (expressed in % VO_2max) and cardiovascular (expressed in % MHRR) load of Nordic and Ordinary Walking. Sub objectives were to analyze influence of speed and slope on the metabolic and cardiovascular load during Nordic and Ordinary Walking.

Our experimental group consisted of ten volunteers (all men), students and employers of the Faculty of Physical Culture, Palacky University in Olomouc. Age range was 26.9±3.5, BMI 23.7±2.2 $kg \cdot m^{-2}$, maximal oxygen consumption (VO_2max) 56±8 $ml \cdot kg^{-1} \cdot min^{-1}$. Measurement was on three slopes (0%, 5%, and 7.5%) and with four speeds (6.0 $km \cdot h^{-1}$, 6.6 $km \cdot h^{-1}$, 7.2 $km \cdot h^{-1}$ and 7.8 $km \cdot h^{-1}$). All test are done in treadmill LODE Valiant in standard laboratory conditions.

Result of our study showed us that oxygen consumption is higher for 3.4 % and heart rate is increased for 5.9 % during Nordic Walking then during Ordinary Walking what was statistically significant.

Nordic Walking is perfect for people who want increase their energy expenditure during some simple physical activity. We can recommend this activity as a perfect way for changing of lifestyle and doing something for their healthiness.

9. SOUHRN

Nordická chůze je relativně nova pohybová aktivita, která zaznamenává obrovský nárůst. Jedná se normální chůzi s speciálními holemi, při které dochází k zapojení více svalů než při běžné chůze. Úkolem diplomové práce bylo sledovat a porovnat metabolické a kardiovaskulární zatížení při nordické a běžné chůzi pomoci spotřeby kyslíku a tepové frekvence. Perspektivou této práce je získat dostatečné množství informací o nordické chůze a jejím dopadu na organismus.

Hlavním cílem mé práce bylo porovnat metabolické (vyjádřeno v % VO_2max) a kardiovaskulární (vyjádřeno v % MTR) zatížení při nordické a běžné chůzi. Dílčími cíli bylo analyzovat vliv sklonu terénu a rychlosti na metabolické a kardiovaskulární zatížení při nordické a běžné chůzi.

Naše experimentální skupina byla tvořena deseti dobrovolníky (všichni muži), studenty a zaměstnanci Fakulty tělesné kultury, University Palackého v Olomouci, ve věku 26,9±3,5 let s BMI 23,7±2,2 $kg \cdot m^{-2}$ a průměrnou hodnotu VO_2max 56±8 $ml \cdot kg^{-1} \cdot min^{-1}$. Měření bylo realizováno na třech sklonech pásu (0%; 5%; 7,5%) a při čtyřech rychlostech (6,0 $km \cdot h^{-1}$; 6,6 $km \cdot h^{-1}$; 7,2 $km \cdot h^{-1}$ a 7,8 $km \cdot h^{-1}$). Všechny testy byly realizovány na běžecké ergometru LODE při standardních laboratorních podmínkách.

Výsledky naše práce nám ukázaly, že spotřeba kyslíku při nordické chůzi je vyšší o 3,4 % a tepové frekvence o 5,9 %, než při chůzi bez holí. Tyto změny byly statisticky významné.

Nordická chůze je ideální pro lidi, kteří chtějí zvýšit svůj energetický výdej během nějaké nenáročné aktivity. Můžeme ji doporučit zejména lidem pro změnu životního stylu a lidem, kteří chtějí udělat něco pro své zdraví.

10. REFERENCES

Blahutková, M., Řehulka, E., & Dvořáková, Š. (2005). *Pohyb a duševní zdraví*. Brno: Paido.

Borg, G. (1982). Psychophysical bases of perceived exertion. *Med Sci Sports Exerc, 14(5)*, 377-381.

Crhová, A. (2010). *Nordic walking aneb ideální pohyb nejen pro bojovníky s nadváhou.* Retrieved 31.5. 2010 from the World Wide Web: http://www.obesity-news.cz/?id=226.

Daněk, K. (1989). *Chůze znovu objevena.* Praha: Olympia.

Frömel, F. (2002). *Kompendium psaní a publikování v kinantropologii*. [Vysokoškolská skripta] Olomouc: Univerzita Palackého, Fakulta tělesné kultury.

Hainer, V. et al. (2004). *Základy klinické obezitologie.* Praha: Grada Publishing.

Hamar, D., & Lipková, J. (2001). *Fyziológia tělesných cvičení*. Bratislava: Univerzita Komenského.

Church, T. S., Earnest, C. P., & Morss, G. M. (2002). Field testing of physiological responses associated with Nordic walking. *Res Q Eserce Sport, 73(3)*, 296-300.

International Nordic Walking Association, (2005). *INWA Instructor manual.* Helsinki: INWA.

Jakubec, A. et al. (2009). Výzkumný design severské chůze ve světle prvních výsledků. *Medicina Sportiva Bohemica Slavatica, 18(4)*, 185-187.

Jirák, Z. et al. (2007). *Fyziologie pro bakalářské studium na ZSF OU* [Učební texty]. Ostrava: Ostravská univerzita v Ostravě, Zdravotně sociální fakulta.

Kaplan, R. M., Sallis, J. F., & Patterson, T. L. (1996). *Zdravie a správanie človeka.* Bratislava: Slovenské pedagogické nakladateľstvo.

Komeštík, B., & Fejte, M. (1997). *Metodologie kinantropologického výzkumu.* Hradec Králové: Vysoká škola pedagogická, Katedra tělesné výchovy a řízení volného času.

Křížová, J. (2007). *Hypertenze – vysoký krevní tlak.* Retrieved 1.6. 2010 from the World Wide Web: http://www.ordinace.cz/clanek/hypertenze-vysoky-krevni-tlak/.

Křížová, J. (2008). *Cukrovka – Diabetes mellitus.* Retrieved 15.6. 2010 from the World Wide Web: http://www.ordinace.cz/clanek/cukrovka-diabetes-mellitus/.

Laukkanen, R. (2009). Research on the benefits of Nordic walking. Retrieved 3. 12. 2009, from the World Wide Web: http://www.Nordicwalkingusa.com/research.htm.

Laukkanen, R. (2010). Scientific evidence on Nordic walking – a summary. Retrieved 1. 7. 2010, from the World Wide Web: http://www.nordicacademy.co.nz/research.html.

Machová, J. et al. (2009). *Výchova ke zdraví.* Praha: Grada Publishing.

Marada, T. (2006). *Ateroskleróza*. Retrieved 10. 5. 2010 from the World Wide Web: http://www.ordinace.cz/clanek/ateroskleroza/.

Mira, M. (2009). *Správná technika Nordic Walking.* Retrived 25. 5. 2010 from the World Wide Web: http://www.severskachuze.cz/wiki/doku.php/chuze/prima_chuze.

Mira, M. (2009). *Původ Nordic Walking.* Retrived 15. 6. 2010 from the World Wide Web: http://severskachuze.cz/wiki/doku.php/chuze/puvod.

Mommertová-Jauchová, P. (2009). *Nordic walking pro zdraví.* Praha: Plot.

Perrey, S., Fabre, N. (2008). Exertion during uphill, level and downhill walking with and without hiking poles. *Journal of Sports Science and Medicine 7***,** 32-38.

Porcari, J. P., Hendrickson, T. L., Walter, P. R. Terry, L., & Walsko, G. (1997). The physiological responses to walking with and without Power Poles an treadmill excercise. *Res Q Exerc Sport, 68(2),* 161-166.

Porcari, J. P. (1999). Pump up your walk. *ACSM'S Health & Fitness Journal.* Jan/Feb, 25-29.

Rodgers, C. D., Vanheest, J. L., & Schacter, C.L. (1995). Energy expenditure during submaximal walking with Exerstriders®. *Med Sci Sports Exerc, 27(4),* 607-611.

Schiffer, T., Knicker, A., Dannohl, R. & Struder, H. K. (2009). Energy cost and pole forces during Nordic walking under different surfaře conditions. *Med Sci Sports Exerc, 41(3),* 663-668.

Sovová, E., Zapletalová, B. & Cyprianová, H. (2008). *100 + 1 otázek a odpovědí o chůzi, nejen nordické.* Praha: Grada Publishing.

Stejskal, P. (2004). *Proč a jak se zdravě hýbat.* Břeclav: Presstempus.

Stejskal, P., & Hejnová, J. (1994). Vyšetření výkonnosti kardiovaskulárního systému pomocí CHR-testu. *Medicina Sportiva Bohemica et Slovaca, 3*, 41-49.

Stejskal, P. Vystrčil, M. (2005). Severská chůze a její využití v tělovýchovném lékařství. *Medicina Sportiva Bohemica Slavatica, 14(4),* 158-165.

Svačina, Š. & Bretšnajdrová, A. (2000). *Obezita a diabetes.* Praha: Maxdorf.

Šonka, J., Doležalová, J., & Žbirková, A. (1990). *Pohybem a dietou proti otylosti.* Praha: Olympia.

Vrtěl, L. (2010). *Vliv rychlosti a sklonu terénu na intenzitu zatížení při severské a běžné chůzi.* Diplomová práce, Univerzita Palackého, Fakulta tělesné kultury, Olomouc.

Vystrčil, M. (2005). *Severská chůze.* Diplomová práce, Univerzita Palackého, Fakulta tělesné kultury, Olomouc.

Willson, J., Torry, M. R., Decker, M. J., Kernozek, T., & Steadman, J. R. (2000). Effects of walking poles on lower extremity gait mechanics. *Med Sci Sports Exersc, 33(1),* 142-147.

Zdraví 21 – zdraví pro všechny v 21. století. (2002). Praha: Ministerstvo zdravotnictví ČR.

Knight, C. A., & Caldwell, G. E. (2000). Muscular and metabolic costs of uphill backpacking: are hiking poles beneficial? *Med Sci Sports Exerc, 32(12),* 2093-101.

11. APPENDIX

1. Average value of all selected indicators for all measured persons during ten minutes of test.
2. Comparison of oxygen consumption during Nordic and Ordinary Walking in different speeds no matter on slope with LSD test.
3. Comparison of oxygen consumption during Nordic and Ordinary Walking in different slopes no matter on speed with LSD test.
4. Comparison of heart rate during Nordic and Ordinary Walking in different speeds no matter on slope with LSD test.
5. Comparison of heart rate during Nordic and Ordinary Walking in different slope no matter on speed with LSD test.
6. Probrant statement

Annex 1.

Average value of all selected indicators for all measured persons during ten minutes of test.

			%VO2max						%MHRR			
person	speed	slope	OW			NW			OW		NW	
	km/h	%	M	SD	VO2/kg	M	SD	VO2/kg	M	SD	M	SD
M1	6	0	24,10	0,94	16,53	24,05	0,96	16,50	22,73	2,21	30,50	1,38
M1	6,6	0	27,49	1,10	18,86	25,05	1,13	17,19	35,01	1,66	38,96	0,65
M1	7,2	0	33,91	0,95	23,27	30,52	1,51	20,94	35,56	1,29	52,46	1,50
M1	7,8	0	38,88	1,18	26,67	40,11	1,56	27,52	48,20	0,85	57,31	2,67
M1	6	5	29,58	0,94	20,29	31,70	0,95	21,74	41,73	1,42	36,41	1,12
M1	6,6	5	37,39	1,10	25,65	36,95	0,99	25,35	41,32	1,47	51,20	1,41
M1	7,2	5	45,80	1,44	31,42	42,42	0,97	29,10	58,60	2,05	52,75	3,61
M1	7,8	5	50,64	1,08	34,74	52,19	1,49	35,80	60,15	2,40	67,13	3,07
M1	6	7,5	30,27	1,36	20,77	37,50	1,29	25,72	31,94	1,52	35,30	2,13
M1	6,6	7,5	43,01	1,10	29,50	34,73	1,22	23,83	47,94	1,25	45,77	2,59
M1	7,2	7,5	50,12	1,70	34,38	52,36	1,75	35,92	54,91	2,86	64,99	3,01
M1	7,8	7,5	58,85	1,53	40,37	65,13	2,52	44,68	68,15	2,55	78,33	3,20
M2	6	0	32,34	2,60	16,10	35,06	1,38	17,46	25,97	1,22	37,54	0,98
M2	6,6	0	37,13	3,32	18,49	40,82	2,48	20,33	40,34	0,93	40,54	2,00
M2	7,2	0	39,92	1,70	19,88	45,41	1,38	22,61	31,67	1,09	49,54	1,29
M2	7,8	0	57,03	3,23	28,40	55,08	2,65	27,43	62,16	1,42	59,70	1,82
M2	6	5	44,86	1,32	22,34	43,67	1,03	21,75	34,56	1,17	42,25	1,04
M2	6,6	5	47,61	1,80	23,71	50,48	2,40	25,14	42,68	1,80	40,36	1,05
M2	7,2	5	60,55	2,81	30,15	63,25	1,29	31,50	56,70	3,43	63,26	1,95
M2	7,8	5	68,08	1,75	33,91	70,99	2,02	35,35	65,19	2,31	78,10	0,75
M2	6	7,5	x	x	x	46,40	1,28	23,11	x	x	41,64	1,11
M2	6,6	7,5	56,41	2,18	28,09	56,46	0,86	28,12	60,65	1,39	60,70	0,79
M2	7,2	7,5	76,08	2,40	37,89	68,54	1,63	34,13	63,19	1,23	70,94	1,92
M2	7,8	7,5	80,77	1,78	40,23	79,82	1,21	39,75	87,11	1,39	84,72	2,20
M3	6	0	27,94	0,87	17,32	26,70	0,85	16,56	31,61	1,35	40,52	1,53
M3	6,6	0	28,17	0,85	17,46	33,31	0,93	20,65	25,15	2,14	45,29	1,63
M3	7,2	0	32,75	1,50	20,31	34,42	0,83	21,34	35,08	1,97	43,80	2,23
M3	7,8	0	38,06	0,87	23,60	37,55	0,80	23,28	47,52	1,46	45,29	1,52
M3	6	5	34,88	0,85	21,63	34,50	1,60	21,39	40,24	1,94	45,00	1,33
M3	6,6	5	42,17	0,97	26,14	35,57	0,76	22,05	48,19	0,87	42,95	1,71
M3	7,2	5	44,35	1,30	27,50	44,83	1,95	27,80	49,74	1,39	55,27	0,86
M3	7,8	5	52,72	1,26	32,68	44,12	1,03	27,35	61,43	2,20	63,53	2,80
M3	6	7,5	37,68	1,61	23,36	33,95	1,16	21,05	45,72	1,82	48,37	1,03
M3	6,6	7,5	41,70	0,86	25,85	43,46	0,96	26,94	46,04	1,19	54,03	2,33
M3	7,2	7,5	48,80	0,80	30,26	47,65	1,57	29,54	56,19	1,35	63,10	2,31
M3	7,8	7,5	55,52	1,29	34,42	51,63	0,67	32,01	73,18	2,85	65,68	8,21
M4	6	0	25,03	1,17	14,84	26,17	1,06	15,52	26,61	1,09	23,34	1,24
M4	6,6	0	26,01	0,91	15,42	33,19	1,06	19,68	36,50	0,94	34,73	2,41
M4	7,2	0	31,71	0,97	18,81	36,73	0,83	21,78	33,31	1,85	40,62	2,08
M4	7,8	0	38,52	1,45	22,84	45,44	1,29	26,95	40,88	1,17	39,62	1,55
M4	6	5	34,71	1,00	20,58	35,60	1,07	21,11	33,21	1,85	35,16	1,98

M4	6,6	5	37,21	0,53	22,07	41,54	1,14	24,64	40,10	1,30	40,09	1,72
M4	7,2	5	40,85	0,61	24,22	51,17	1,01	30,34	41,26	2,51	54,64	2,25
M4	7,8	5	49,15	1,15	29,15	52,32	1,52	31,03	55,32	3,17	63,05	2,55
M4	6	7,5	40,18	0,86	23,83	40,12	0,64	23,79	37,22	0,89	36,07	0,93
M4	6,6	7,5	44,42	0,75	26,34	46,60	0,85	27,64	43,87	0,88	50,66	3,03
M4	7,2	7,5	50,76	0,91	30,10	53,80	1,66	31,90	49,20	2,31	57,07	3,96
M4	7,8	7,5	61,90	2,36	36,71	66,58	1,18	39,48	70,50	2,84	79,19	3,28
M5	6	0	30,14	1,33	16,18	30,14	1,33	16,18	35,09	1,20	35,09	1,20
M5	6,6	0	43,21	1,22	23,20	43,21	1,22	23,20	46,58	1,30	46,58	1,30
M5	7,2	0	45,18	1,51	24,26	45,18	1,51	24,26	48,77	1,10	48,77	1,10
M5	7,8	0	32,10	2,19	17,24	32,10	2,19	17,24	38,54	1,42	38,54	1,42
M5	6	5	45,58	1,40	24,48	45,58	1,40	24,48	49,87	1,10	49,87	1,10
M5	6,6	5	51,26	1,50	27,53	51,26	1,50	27,53	55,09	1,67	55,09	1,67
M5	7,2	5	44,08	1,47	23,67	44,08	1,47	23,67	47,46	1,31	47,46	1,31
M5	7,8	5	58,77	1,33	31,56	58,77	1,33	31,56	64,30	2,62	64,30	2,62
M5	6	7,5	61,65	1,67	33,11	61,65	1,67	33,11	73,17	1,19	73,17	1,19
M5	6,6	7,5	52,75	1,31	28,33	52,75	1,31	28,33	57,65	2,10	57,65	2,10
M5	7,2	7,5	66,13	1,42	35,51	66,13	1,42	35,51	73,31	3,91	73,31	3,91
M5	7,8	7,5	73,00	1,25	39,20	73,00	1,25	39,20	82,24	2,00	82,24	2,00
M6	6	0	41,05	1,48	18,10	39,00	1,25	17,20	26,96	1,27	30,47	1,26
M6	6,6	0	51,81	1,79	22,85	54,67	1,71	24,11	38,22	2,20	42,53	1,40
M6	7,2	0	58,03	1,43	25,59	59,15	1,90	26,09	42,02	1,65	40,44	1,79
M6	7,8	0	51,08	1,01	22,53	45,27	2,31	19,97	31,63	1,11	37,65	1,48
M6	6	5	61,13	2,02	26,96	56,43	1,31	24,88	45,64	1,26	47,25	1,63
M6	6,6	5	64,80	2,14	28,58	63,49	2,17	28,00	50,28	1,58	50,79	1,68
M6	7,2	5	51,91	1,49	22,89	52,10	3,79	22,97	40,23	2,05	48,40	2,56
M6	7,8	5	69,72	1,69	30,75	69,28	2,08	30,55	52,18	1,44	53,82	1,13
M6	6	7,5	70,94	1,12	31,28	86,47	2,74	38,13	56,76	2,20	61,66	2,11
M6	6,6	7,5	62,83	2,46	27,71	60,46	2,15	26,66	48,34	1,73	52,55	2,11
M6	7,2	7,5	81,61	3,32	35,99	70,66	2,13	31,16	70,86	2,38	67,36	3,32
M6	7,8	7,5	82,35	3,17	36,32	86,73	1,86	38,25	70,87	2,44	79,67	2,67
M7	6	0	29,85	0,99	17,20	29,62	0,87	17,06	32,12	1,03	39,42	0,55
M7	6,6	0	34,19	1,13	19,69	43,86	1,36	25,26	31,23	1,10	41,79	1,41
M7	7,2	0	44,97	1,90	25,90	49,92	1,58	28,75	38,51	1,17	44,37	1,83
M7	7,8	0	30,21	0,76	17,40	34,91	1,35	20,11	30,37	0,63	34,72	0,94
M7	6	5	42,19	1,15	24,30	43,51	1,19	25,06	39,59	0,81	46,92	1,54
M7	6,6	5	44,89	1,39	25,86	54,37	1,58	31,32	39,74	0,95	49,10	1,26
M7	7,2	5	42,21	1,62	24,31	40,50	1,62	23,33	37,68	0,78	45,21	2,82
M7	7,8	5	50,61	1,25	29,15	56,58	1,18	32,59	49,36	2,33	57,55	2,17
M7	6	7,5	57,03	1,73	32,85	58,82	1,89	33,88	49,87	1,24	59,65	2,48
M7	6,6	7,5	40,02	1,08	23,05	50,54	1,75	29,11	41,19	1,48	47,85	1,17
M7	7,2	7,5	55,92	1,54	32,21	63,50	1,34	36,57	53,68	2,07	58,58	2,78
M7	7,8	7,5	68,00	1,82	39,17	74,27	1,25	42,78	58,42	2,50	63,84	1,75
M8	6	0	22,48	0,94	14,79	21,66	1,48	14,25	31,17	1,45	28,71	1,45
M8	6,6	0	32,04	0,63	21,08	35,55	1,73	23,39	38,30	0,93	38,75	1,64
M8	7,2	0	33,83	1,08	22,26	39,30	1,26	25,86	40,28	1,14	46,36	0,97
M8	7,8	0	21,66	0,69	14,25	27,17	1,18	17,88	34,74	1,33	34,52	0,80
M8	6	5	29,49	0,82	19,40	34,57	1,29	22,75	41,80	1,26	41,65	1,37
M8	6,6	5	38,97	0,55	25,64	43,60	1,14	28,69	44,47	0,83	49,68	1,55

M8	7,2	5	29,59	1,69	19,47	24,55	1,50	16,15	36,83	1,32	42,43	1,06
M8	7,8	5	39,63	0,70	26,08	33,12	0,80	21,79	46,36	1,32	59,83	1,92
M8	6	7,5	48,11	1,55	31,65	47,29	1,28	31,12	53,72	1,63	52,68	1,80
M8	6,6	7,5	29,29	0,71	19,27	39,41	1,22	25,93	41,58	0,95	46,26	1,60
M8	7,2	7,5	44,70	2,05	29,42	57,11	1,31	37,58	50,30	0,94	64,06	1,35
M8	7,8	7,5	49,07	1,27	32,29	47,86	1,86	31,50	60,73	1,07	63,63	1,11
M9	6	0	36,12	1,13	17,81	37,79	1,28	18,63	35,05	1,16	34,40	1,30
M9	6,6	0	42,86	1,51	21,13	47,95	1,26	23,64	33,08	1,19	38,57	2,42
M9	7,2	0	48,80	0,81	24,06	51,55	1,71	25,41	43,44	1,74	49,94	4,68
M9	7,8	0	36,71	1,64	18,10	41,31	0,98	20,37	36,04	1,03	35,00	2,49
M9	6	5	46,83	0,63	23,09	57,89	1,27	28,54	39,33	0,89	50,52	1,25
M9	6,6	5	56,20	0,89	27,71	58,84	1,32	29,01	44,28	0,82	56,03	2,37
M9	7,2	5	40,58	1,00	20,01	47,12	1,06	23,23	34,45	1,06	42,28	1,84
M9	7,8	5	55,13	0,82	27,18	60,40	1,34	29,78	49,45	1,20	64,29	1,40
M9	6	7,5	62,11	0,94	30,62	67,18	1,95	33,12	56,16	1,89	51,42	2,81
M9	6,6	7,5	52,92	0,79	26,09	61,99	2,03	30,56	41,93	1,13	56,05	4,83
M9	7,2	7,5	60,84	0,85	30,00	70,36	1,11	34,69	58,18	1,01	55,45	2,22
M9	7,8	7,5	73,82	2,33	36,39	77,04	1,95	37,98	65,19	2,55	71,48	1,34
M10	6	0	28,65	0,59	14,27	41,30	1,50	20,57	26,37	0,81	39,34	1,55
M10	6,6	0	41,37	0,80	20,60	55,03	1,29	27,41	35,98	1,24	58,36	2,84
M10	7,2	0	44,52	1,11	22,17	55,99	1,53	27,88	40,78	1,72	53,68	1,57
M10	7,8	0	30,82	1,14	15,35	55,34	1,21	27,56	29,93	2,35	62,60	1,74
M10	6	5	44,93	1,42	22,37	57,95	0,88	28,86	40,04	1,31	63,31	1,94
M10	6,6	5	50,82	1,26	25,31	64,32	2,06	32,03	48,46	2,12	75,46	1,21
M10	7,2	5	40,54	1,54	20,19	59,26	1,07	29,51	40,22	0,77	72,41	1,56
M10	7,8	5	53,95	1,34	26,87	63,94	1,38	31,84	49,50	2,01	71,77	2,14
M10	6	7,5	60,39	1,00	30,07	78,31	1,33	39,00	52,39	2,20	74,63	1,40
M10	6,6	7,5	48,23	1,27	24,02	77,27	1,58	38,48	50,22	2,18	72,89	2,05
M10	7,2	7,5	57,87	1,14	28,82	73,34	1,44	36,52	63,59	2,68	76,02	1,33
M10	7,8	7,5	66,26	0,81	33,00	87,71	1,52	43,68	75,39	2,81	82,35	2,26

Legend: M – arithmetic's average, SD – standard deviation, OW – Ordinary Walking, NW – Nordic Walking, % VO_2max – percent of maximal oxygen consumption, % MHRR – present of maximal heart reserve, x – not measured values because of loosing data, M1 – M10 – man 1 to man 10.

Annex 2

Comparison of oxygen consumption during Nordic and Ordinary Walking in different speeds no matter on slope with LSD test.

	OW X NW	
speed	difference	p
6	1,38	0,03
6,6	4,71	0,001
7,2	2,75	0,03
7,8	6,21	0,001

Legend: OW – Ordinary Walking, NW – Nordic Walking, p – level of statistical significance.

Annex 3

Comparison of oxygen consumption during Nordic and Ordinary Walking in different slopes no matter on speed with LSD test.

	OW X NW	
slope	difference	p
0	3,76	0,001
5	2,99	0,006
7,5	3,05	0,003

Legend: OW – Ordinary Walking, NW – Nordic Walking, p – level of statistical significance.

Annex 4

Comparison of heart rate during Nordic and Ordinary Walking in different speeds no matter on slope with LSD test.

	OW X NW	
speed	difference	p
6	4,57	0,002
6,6	6,43	0,001
7,2	11,21	0,000
7,8	5,55	0,001

Legend: OW – Ordinary Walking, NW – Nordic Walking, p – level of statistical significance.

Annex 5

Comparison of heart rate during Nordic and Ordinary Walking in different slope no matter on speed with LSD test.

	OW X NW	
slope	difference	p
0	6,94	0,000
5	5,81	0,000
7,5	4,78	0,000

Legend: OW – Ordinary Walking, NW – Nordic Walking, p – level of statistical significance.

Annex 6

Probrant statement

Jméno a příjmení: .....

Prohlášení

Potvrzuji, že jsem byl(a) seznámen(a) s obsahem a s podmínkami zařazení do výzkumného projektu: „**Fyziologické a biomechanické aspekty severské chůze a jejich využití v praxi**“.
Má účast na projektu je dobrovolná a jedinou odměnou mi budou informace z jednotlivých vyšetření. Souhlasím s anonymním užitím zjištěných výsledků k vědeckým účelům. Podle svého subjektivního názoru jsem zdravý(á) a nebylo u mne diagnostikované žádné onemocnění, pro které bych nemohl(a) podstoupit zátěžová vyšetření.

V Olomouci dne: Podpis: