International Journal of Physical Education, Sports and Health 2016; 3(3): 06-13

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (ISRA): 4.69
IJPESH 2016; 3(3): 06-13

www.kheljournal.com
Received: 17-03-2016
Accepted: 20-04-2016

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Earthing modulates glucose and erythrocytes metabolism in exercise

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Abstract
Earthing is a direct contact with the earth or indirect with the use of a metal conductor. The earthing eliminates potentials on body and influences physiological processes. We examined whether the earthing influences glucose, lactate and bilirubin concentration in exercise and relaxation.

In a double-blind, crossover study, 42 participants divided into two groups basing on their utilization oxygen were earthed during exercise and recovery sessions. In the first experiment group A was earthed, group B unearthed, in the second experiment in the opposite way. The mean weight of participants in group A was 77, 1 and 72,8 in group B. For the earthed group, after 15min of exertion we observed a rise, after 30min decrease in glucose concentration, and in the 40min of relaxation a secondary rise.

For unearthed participants, we noted a decrease in glucose concentration after 15min of exertion and a gradual rise later on. The baseline concentration of bilirubin was higher after earthing (p=0,006) in group A (0,91±0,50) than in group B (0,55±0,22) and without earthing the difference was not significant (p=0,13) in group A (0,85±0,46) and in group B (0,65±0,35). Earthing caused elevation of bilirubin concentration in group A and reduction in group B both in exercise and relaxation.

It indicates that earthing modulates metabolism of erythrocytes and adjusts it to level of proper body mass as a functional dielectric. Earthing during exercise helps the training organism to mobilize plasma glucose for its muscular uptake and facilities more effective utilization in energetic processes.

Keywords: earthing, glucose, bilirubin, exercise, metabolism

Introduction

Earthing can be defined as a direct contact of human with the earth during barefoot walking, running on grass, soil or while swimming in natural water reservoir. Earthing can be accomplished by indirect contact with the earth by a grounded metal conductor connected e.g. to the subject's ankle of the leg. During the earthing, electrical charge does not merely remain on surface of the body and neutralize a surface positive charge, but also changes the potential in the aqueous environment of extracellular compartment of human organism. Earthing is associated with the supply of a negative charge [1]. The contact via cooper conductor with the earth causes elimination of the potential on surface of human body and leads to equalization with the potential of the earth [1, 2]. Previous studies showed that up and down movement of unearthed human causes transient changes in electrical potential at selected measurement points. During the same movement, the electrical potential of the earthed person remains constant [1]. Chevalier noted immediate decrease in skin conductance after earthing [3]. In our studies we observe similar alterations in electrical potential: in earthed subject the amplitude of this potential is low and equals from -6 to +6 mV. In the unearthed the changes of amplitude during the motion are greater from -400 to +400 mV [1, 4]. When the body is grounded, its electrical potential becomes equalized with the earth's electrical potential [2].

The contact with the earth influences physiological processes [5]. It is associated with the lowering of blood concentrations of sodium, potassium, magnesium, iron, ionized calcium, inorganic phosphorus, and reduction of renal excretion of calcium and phosphates. The earthing decreases blood glucose in patients with diabetes and causes reduction of serum concentrations of total protein and albumins while it increases the concentration of globulins. Seven-hour earthing of lower extremities in a night rest causes statistically significant lowering of serum concentration of iron and increase of transferrin and ferritin [5].

Earthing influences on surface charge of erythrocytes and reduces blood viscosity what was proved by excellent study performed by Chevalier *et al.* [6]. Several reports present the effects of the earthing during the rest [7]. In a recently published study we demonstrated that earthing during the exercise lowers blood urea concentrations during physical exercise and relaxation and thus may inhibit the protein catabolism or the increase of renal urea excretion [4]. We showed that earthing during exercise changes the protein metabolism and reduces urea production and can have influence of kidney filtration.

Exertion under earthing may result in positive protein balance [4].

In this study, we test the hypothesis whether the contact of human body with the earth using cable conductor during the exertion and relaxation influences glucose and lactate metabolism and bilirubin concentration as an end product of hemoglobin catabolism.

Material and methods

Forty-two male volunteers were selected from a group of 60 students at the University of Physical Education and Sport in Gdansk, Poland. All of the participants were informed about details of the experiment and gave written consent. The ethics committee approved the investigation, which was conducted according to the principles expressed in the Declaration of Helsinki. Participants had no requirements or restrictions regarding their daily diet. Selection of the volunteers was based on an exertion test performed on a bicycle ergometer and on analysis of expired gases with the use of the Oxycon Pro analyzer (Jaeger, Wuerzburg, Germany). Volunteers were divided into two groups (A and B) based on maximal oxygen uptake (VO_{2max}) values. Subjects (n=18) with the highest and lowest values of VO_{2max} were excluded. Cut-offs were as follows: minimal VO_{2max} = 40 ml/kg/min and maximal VO_{2max} = 60 ml/kg/min. The other subjects (n=42) were divided into two homogeneous groups consisting of 21 participants each (Table 1). The crossover technique was applied. In the first week of the experiment, individuals from group A were earthed (A_o) and those from group B were unearthed (B_1). In the second week of the experiment, individuals from group A were unearthed (A_1) and those from group B were earthed (B_0). None of the participants knew if he was to be earthed for 70 minutes (30 minutes training exercise and 40 minutes of recovery) in the first or in the second week of the experiment. Tested persons had to perform two training exercises lasting 30 minutes on a bicycle ergometer once with earthing, and the second time without earthing to the limit of 50% of VO_{2max}. Recovery lasted 40 minutes.

We measured the electrical potential of the body and blood parameters. Blood samples were obtained before each training session, after 15 minutes of exercise, after 30 minutes of exercise, and after 40 minutes of recovery. During training, continuous monitoring of physiological parameters was performed. Earthing was performed with the system consisting of four metal-plastic hypoallergenic bands wrapped around the ankle of the leg at the beginning of the trial. Bands were connected to conductors with a terminator clamp placed on plumbing pipe. All participants had wrapped bands around their ankles connected to a cable leading to a pipe through a switch, which enabled earthing to be turned on and off. None of the participants knew if he was connected or disconnected. The Pomona Electronics (Everett, WA, USA) system was used to earth the subjects during the exercise test. The effectiveness of earthing of the person being tested and the person performing the test was checked using the certified tester, Pomona 6086. Biochemical analysis was conducted with the use of the A-15 analyzer (Biosystems SA, Costa-Brava, Barcelona, Spain). Glucose and lactate concentrations were measured enzymatically with glucose oxidase, lactate oxidase and peroxidase. Bilirubin concentrations were measured enzymatically (mg/dl).

Statistical analysis of the results was performed using repeated measures analysis of variance with a grouping variable followed by post-hoc Fisher's least significant difference (LSD) test with alpha set at 0.05. The repeated measures factors were as follows: 1) earthing or the lack of earthing; and 2) four different time points of measurement (rest, the 15th minute of exercise, the 30th minute of exercise, and the 40th minute of rest). Grouping factors were in the order in which the subjects were earthed. Intergroup comparisons (earthed *vs* unearthed) were performed. p value <0.05 was accepted as the level of statistical significance. To minimize the familywise probability of a type I error, only between-subject comparisons at the times 0, 15, 30, and 40 minutes were considered. All calculations were performed in Statistica version 10 (StatSoft, Inc., Tulsa, OK, USA).

Table 1a: Characteristics of participants in groups A and B. Parameters of participants of the experiment

	Group A (n=21)	Group B (n=21)
Age [years]	21.0±1.00	21.1±0.89
Weight [kg]	77.1±10.05	72.8±6.22
Height [cm]	183.6±6.17	182.2±6.15
VO_2 max	50.8±4.17	50.7±3.95

Table 1b. Conditions of the experiment

Date	Start time	Temperature [°C]	Humidity [%],	Pressure [hPa]	Altitude [m]
	First w eek Group; A_0+B_1				
08.05	12.55	20	51	1017	16
09.05	07.53	19	49	1013	16
10.05	11.01	21	53	1014	16
11.05	08.05	23	54	1010	16
12.05	13.59	20	48	1016	16
14.05	14.01	20	48	1016	16
15.05	13.37	21	48	1008	16
	Second week Group; A_1 +B_0				
16.05	08.33	19	50	1003	16
17.05	13.49	19	48	1010	16
18.05	08.17	18	47	1013	16
19.05	14.07	20	48	1012	16
21.05	14.08	24	60	1005	16
22.05	14.05	25	62	1008	16
23.05	08.02	23	62	1015	16

Results

Studies were conducted in a homogenous group of men in the same room. Humidity and air temperature were similar in the first and the second week of experiment. Mean atmospheric pressure in the first week was 1013 hPa, in the second week 1009, 4 hPa. 50% VOmax in group A was 50, 8±4,7, in group B was 50,7±4,95 ml O2/kg (p≤0,6). Mean weight in group A was 77, 1±10,05 kg and 72,8±6,22 kg in group B (p≤0,13).

Oxygen consumption is displayed in fig. 1 a,b,c. In a group B (with lower weight) there is significant lower oxygen consumption at the end of the exertion when they are earthed. For the earthed group, after 15th minute of exertion we observed a rise in glucose concentration, after 30th minute a decrease in glucose concentration, and in the 40th minute of recovery, a secondary rise in glucose concentration (Fig.2a).

For unearthed participants in group A, we noted a decrease in glucose concentration after 15th minute of exertion and a gradual rise in glucose concentration after 30th minute of exertion and 40th minute of recovery (Fig.2b). The dynamic curve of glucose concentration in the unearthed group B was horizontal (Fig. 2c) Dynamic curves of glucose concentrations were un-correlated when comparing the earthed and unearthed males. The corresponding lactate concentration curves were highly correlated in the groups of earthed and unearthed subjects. The highest concentration of lactates was observed in the 15th minute of exertion. (Fig.3 a,b,c). Between-group differences were not statistically significant.

Bilirubin plasma concentration in group A was significantly higher in both subgroups: earthed and unearthed than in groups B0 and B1. We noted statistically significant difference (p=0,006) in baseline levels of bilirubin between groups A with higher weight and B with lower weight when the subjects were earthed in the exertion and relaxation. The mean difference in baseline is 0,36mg/ml. The baseline concentration of bilirubin was higher after earthing in group A (0,91±0,50) than in group B (0,55±0,22) and without earthing the difference was not significant (p=0,13) in group A (0,85±0,46) in group B (0,65±0,35).

Earthing in group A caused significant rise in bilirubin concentration (A0) in comparison to unearthed (A1) in the 15th and 30th minute of exercise and and in the 40th minute of relaxation Earthing in group B caused significant reduction of bilirubin concentration (B0) in comparison to unearthed (B1) both in the exercise and relaxation (Fig. 4 a,b,c) (Table 2).

There are no statistically significant alterations in erythrocyte amount in 1 mm^3 (Table 3). We observe reduction of hemoglobin concentration (g/100ml) after 15min of exertion and 40min of relaxation in group B in earthed B0 in comparison to unearthed B1 (Table 4). Significant rise in MCV (μm^3) in earthed from group B after 15 min of exertion (B0) and earthed from group A after 40 min of relaxation in comparison to unearthed was also noted (Table 5).

Table 2: Bilirubin concentrations in groups A and B Statistical significance in comparison between groups *A0-A1 I,II,III,IV, B1-B0 I,II,III,IV, B1A0 I,II,III,IV

	I rest	II (15min)	III (30min)	IV (40 min of relaxation)
A0 earthed	0,91±0,50 I-II-III	0,95±0,51 II-I	0,98±0,53 III-I-IV	0,93±0,50 IV-III
A1 unearthed	0,85±0,46 I-II-III	0,88±0,47 II-I-IV	0,88±0,43 III-I	0,85±0,43 IV-II
B0 earthed	0,55±0,22 I-II-III	0,58±0,24 II-I	0,58±0,24 III-I	0,56±0,22
B1 unearthed	0,65±0,35	0,68±0,41	0,58±0,42	0,66±0,38

Table 3: Changes in amount of erythrocytes (T/l) in exertion and recovery

	I (rest)	II (15min of exertion)	III (30min of exertion)	IV (40 min of recovery)
A0	5,07±0,24 *I-II-III	5,28±0,25 *II-IV	5,29±0,33 *III-IV	5,10±0,32
A1	5,03±0,27 *I-II-III	5,26±0,31 *II-IV	5,25±0,21 *III-IV	5,06±0,29
B0	5,00±0,28 *I-II	5,12±0,28 *II-IV	5,10±0,43 *III-IV	4,96±0,38
B1	5,11±0,32*I-II	5,23±0,28 *II-IV	5,21±0,28 *III-IV	5,08±0,41

* significant differences between phases at *p*<0.05

Table 4: Changes in hemoglobin (g/dl) concentration

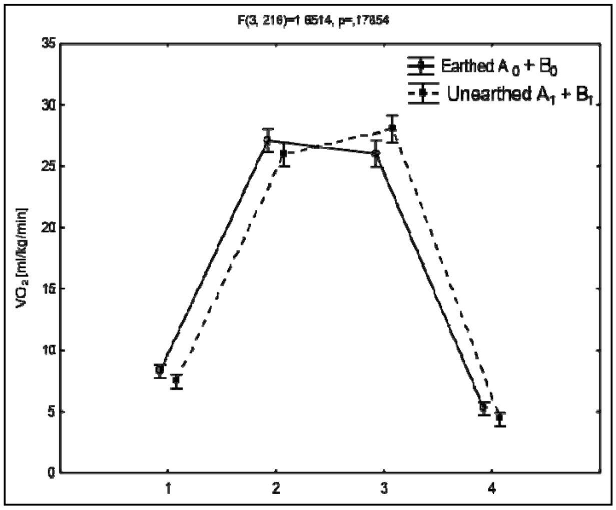
	I (rest)	II (15min of exertion)	III (30min of exertion)	IV (40 min of rest)
A0	15,25±0,56 *I-II-III	15,92±0,81 *II-IV	15,97±1,05 *III-IV	15,36±0,94
A1	15,15±0,88 *I-II-III	15,86±0,97 *II-IV	15,84±0,69 *III-IV	15,21±0,66
B0	15,05±0,80 *I-II-III	^15,46±0,87 *II-IV	15,55±0,85 *III-IV	^15,01±0,83
B1	15,37±0,90 *I-II-III	^15,83±0,87 *II-IV	15,73±0,95 *III-IV	^15,39±0,96

* Significant differences between phases at *p*<0.05
^ Significant differences between groups at *p*<0.05

Table 5: Changes in MCV (fl) in exertion and recovery

	I (rest)	II (15min of exertion)	III (30min of exertion)	IV (40 min of recovery)
A0	86,87±3,11 *I-II-III	86,39±3,05 *II-IV	86,59±3,13 *III-IV	^86,88±3,02
A1	86,72±3,39	86,62±3,44	86,55±3,39	^86,61±3,26
B0	87,41±3,16	^87,28±3,33 *II-IV	87,42±3,11	87,38±3,32
B1	87,17±3,27	^86,99±3,35	87,24±3,52	87,29±3,51

* significant differences between phases at *p*<0.05 ^significant differences between groups at *p*<0.05



1. (I) the beginning of the experiment (earthed or unearthed)
2. (II) 15 minutes after the start of exertion
3. (III) 30 minutes after the start of exertion
4. (IV) 40 minutes of the recovery

Fig 1a: Dynamic curves of oxygen consumption in 42 earthed (A_0+B_0) and 42 unearthed subjects (A_1+B_1) x-axis

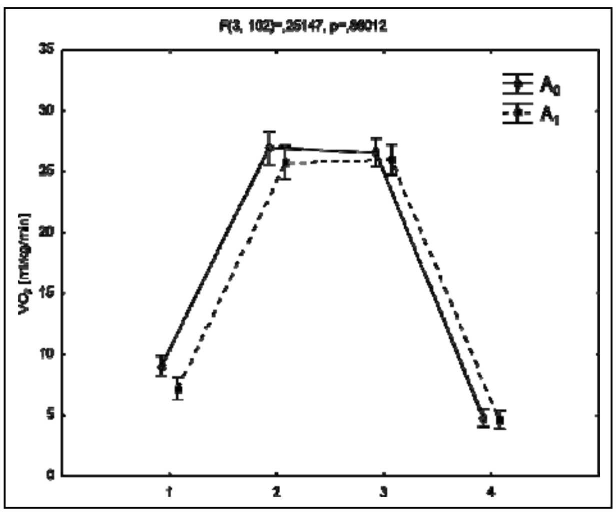


Fig 1b: Dynamic curves of oxygen consumption in 21 earthed (A_0) and 21 unearthed (A_1) subjects

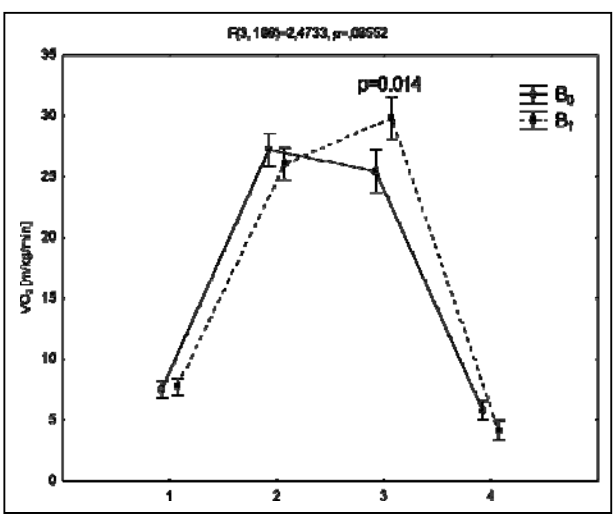


Fig 1c: Dynamic curves of oxygen consumption in 21 earthed (B_0) and 21 unearthed (B_1) subjects

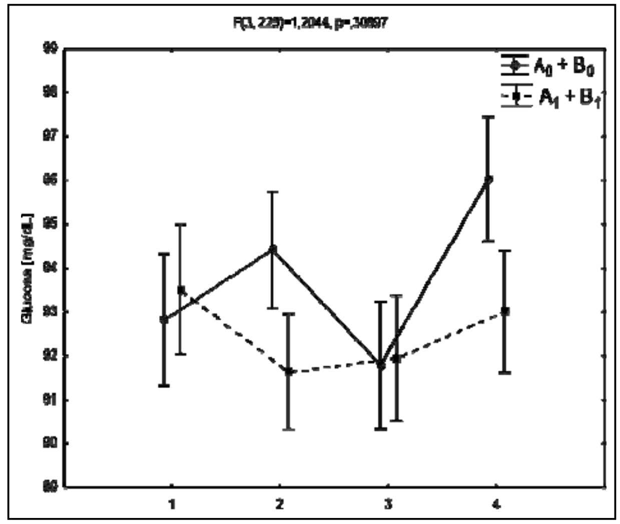


Fig 2a: Dynamic curves of blood glucose concentrations in 42 earthed (A_0+B_0) and unearthed (A_1+B_1) subjects in two weeks

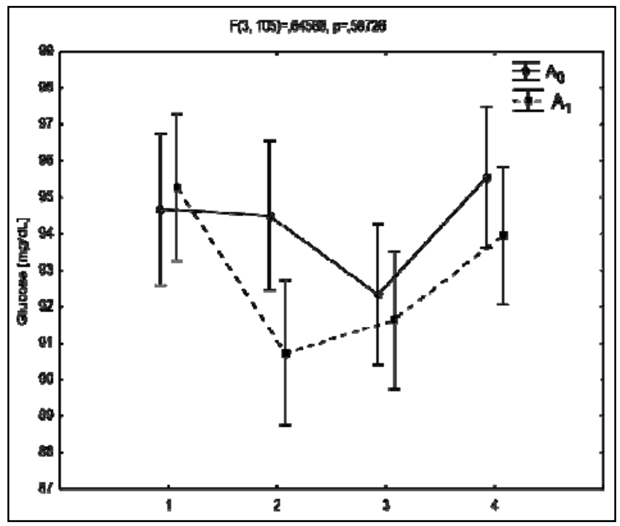


Fig 2b: Dynamic curves of blood glucose concentrations of glucose in 21 earthed (A_0) in the first week and unearthed (A_1) in the second week subjects

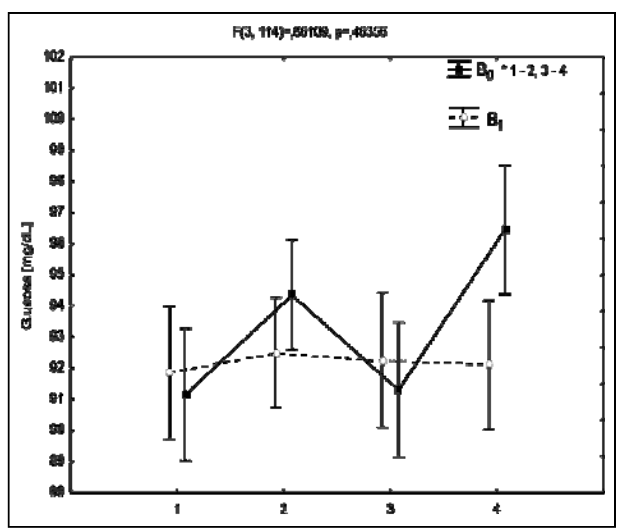


Fig 2c: Dynamic curves of blood glucose concentrations in 21 earthed (B_0) in second week and unearthed (B_1) in first week subjects (* significant differences between phases at *p*<0.05).

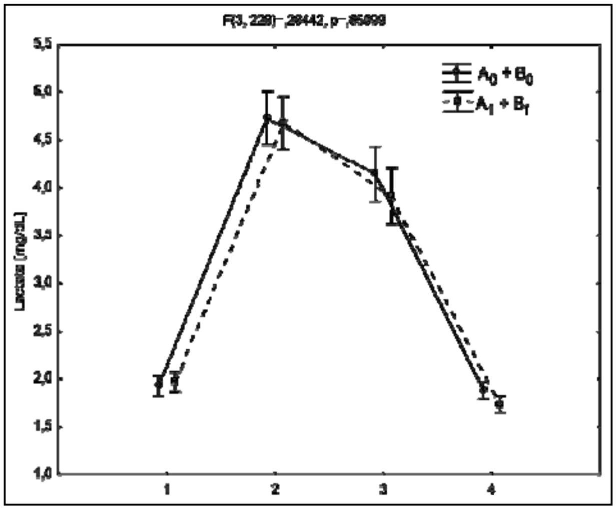


Fig 3a: Dynamic curves of blood lactate concentrations in 42 earthed (A_0+B_0) and unearthed (A_1+B_1) subjects in two weeks

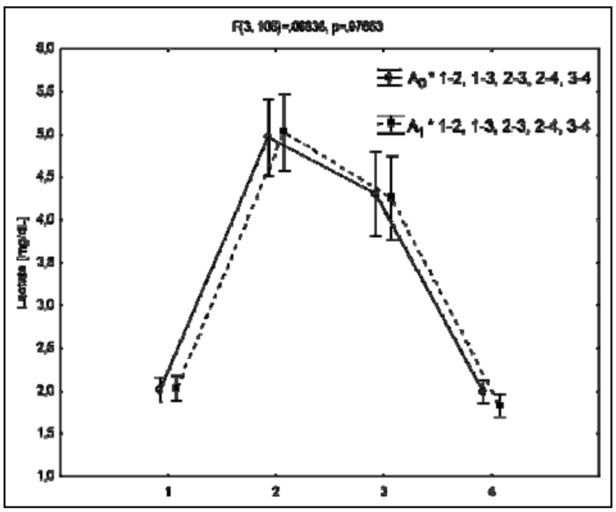


Fig 3b: Dynamic curves of blood lactate concentrations of lactate in 21 earthed (A_0) in first week and unearthed (A_1) in second week subjects (* significant differences between phases at p<0.05)

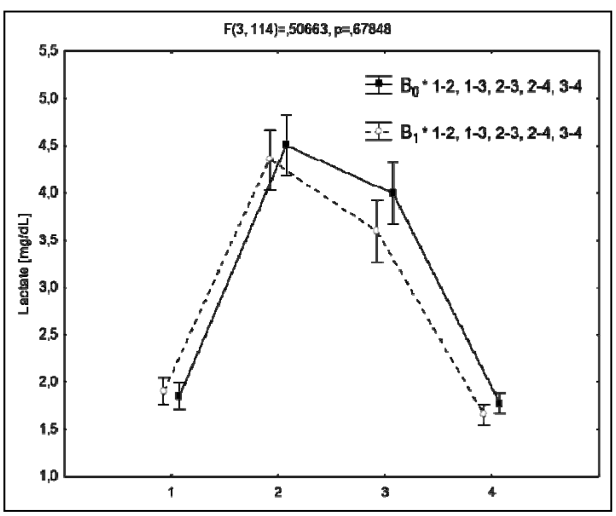


Fig 3c: Dynamic curves of blood lactate concentrations in 21 earthed (B_0) in second week and unearthed (B_1) in first week subjects. (*significant differences between phases at p<0.05)

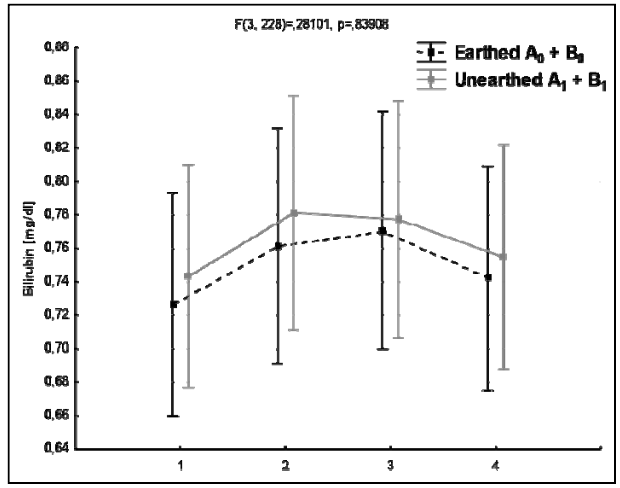
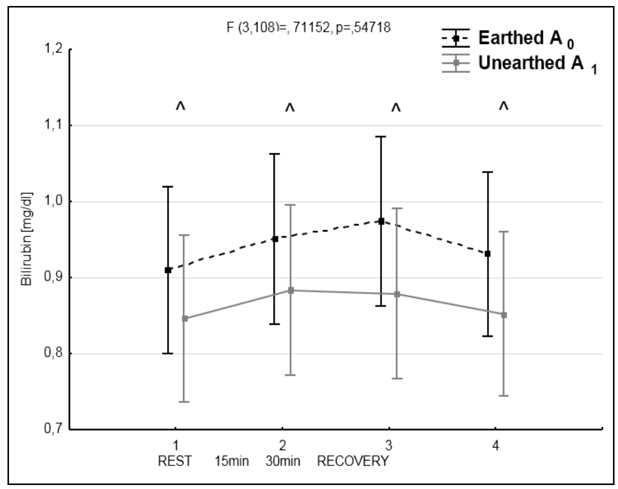
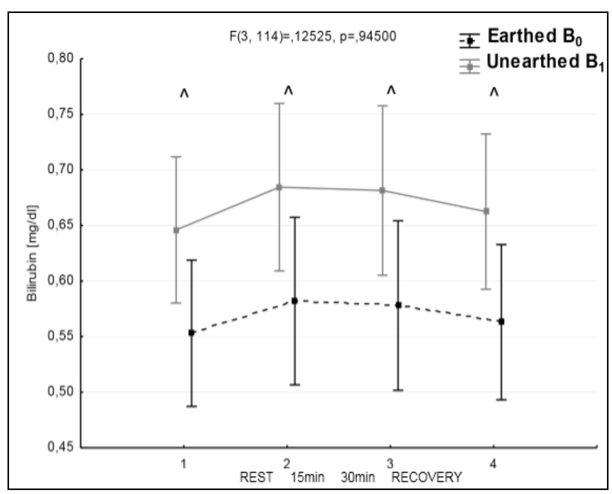


Fig 4a: Changes in bilirubin (mg/dl) concentration in earthed and unearthed



^ Significant differences between groups at p<0.05
A0, significant differences between phases at p<0.05 (*1-2-3; 3-4)
A1, significant differences between phases at p<0.05 (*1-2-3; 2-4)

Fig 4b: Changes in bilirubin (mg/dl) concentration in earthed subgroup A0 and unearthed subgroup A1



^ Significant differences between groups at p<0.05
B0, significant differences between phases at p<0.05 (*1-2-3)

Fig 4c: Changes in bilirubin (mg/dl) concentration in earthed subgroup B0 and unearthed subgroup B1

Discussion

Interpretation of results of these studies posed difficulties since we observed different effects of earthing on various parameters in groups A and B. Oxygen consumption on 1kg of mass in groups A and B was comparable. Total oxygen consumption was dependent on body mass but we did not received statistical significance. It can be the result of different grade of training of the participants. There is a correlation between maximal oxygen consumption and amount of hemoglobin circulating in blood [8]. In healthy children and young individuals there is correlation between the blood volume, human mass, body's surface and height [9]. Chevalier *et al*. proved that blood oxygenation variance is decreased during earthing, followed by a dramatic increase after interruption of contact with the earth [3]. In our study in the group B which consisted of subjects with lower weight the oxygen consumption at the end of the exercise was elevated when these subjects were not earthed. It means that when the subjects were earthed they didn't need to consume too much oxygen as though they had to perform the same exercise without earthing. Statistically significant lower oxygen utilization at the end of the exercise in earthed subjects with lower weight suggests dominance of anabolic processes in this group. Earthed subjects with lower weight can have predominance of anabolic processes, subjects with higher weight under earthing can present predominance of catabolic processes. In this study a homogeneous group of young, healthy men with similar aerobic endurance measured by maximal oxygen uptake was selected. These people had to perform the same cycling exercise in two weeks of experiment once earthed and the second time without earthing or vice versa depending on the group they belonged.

Effects of earthing on glucose metabolism

Circulating blood glucose is a very important metabolic fuel and a number of mechanisms are used to maintain adequate blood glucose levels [10]. Plasma glucose during exertion comes from glycogenolysis, gluconeogenesis or from a digestive tract. Glycogen is a major storage carbohydrate in our body. It is stored mainly in the liver and skeletal muscle. Glycogenolysis occurs in liver during the periods of fasting to maintain blood glucose level. Muscle glycogen does not directly provide free glucose due to the lack of glucose 6-phosphatase enzyme in muscle. In exercise the glycogenolysis dominates in an early stage during high intensity exercise. The states of hypoglycaemia and hyperglycemia can occur during the exercise, whereas plasma glucose concentration usually remains relatively constant. As the blood glucose level rises it stimulates the release and synthesis of insulin. The glucose production in the liver increases during exercise due to hepatic glycogenolysis and gluconeogenesis. The former dominates during intense exercise. Gluconeogenesis occurs in a prolonged exercise [11]. The glucose utilization increases with the intensity of exercise and its duration, thereby partially compensates for the progressive decrease in the muscle glycogen concentration. The plasma glucose utilization is lower in the trained state [12].

Glucose can be metabolized via alternative pathways depending upon needs of cell and body. During the exercise glucose is utilized in muscle cells. In an anaerobic metabolism, lactic acid accumulates in the extracellular environment during exercise. Although most organs generate lactic acid, the largest amounts are produced by skeletal muscle, erythrocytes and skin. Under normal conditions lactic acid is eliminated by metabolic destruction of the acid rather than by urinary excretion [13].

The study revealed differences in blood glucose concentration during the exercise. The metabolism of glucose and lactate during exertion behaves in a different way in the earthed subjects and the same subjects who are not earthed. The exercise stimulates the uptake in skeletal muscles. When the duration of the exercise increases there is an increase in glucose uptake compensating for the progressive decrease in muscle glycogen concentration. Increased blood glucose results in enhanced glucose uptake and disposal during the exercise. The reduced levels of blood glucose may limit muscle glucose uptake [14]. In our experiment we observe the tendency of blood glucose level to rise in the 15th minute of exercise. 15 minutes after the onset of exertion the earthed subjects have higher blood glucose concentration in comparison to the unearthed subjects regardless of the week in which they were earthed. It suggests that earthing during exertion mobilizes glucose pool faster for more effective and quicker utilization and accelerates thus muscle glucose uptake, what is observed especially in the group with lower mean weight [fig.1c]. The increased blood glucose pool during early exercise possibly comes from glycogenolysis in liver. Muscle glycogen does not directly provide free glucose due to the lack of glucose 6-phosphatase enzyme in muscle. Quite likely hepatic glycogen is the source of increased plasma glucose in the first 15 minutes [10]. The glycogenolysis dominates in early intensive exercise. The rate of gluconeogenesis is increased when exercise is prolonged. In our study hepatic glycogenolysis may be intensified in people earthed during first 15 minutes of exercise. Later on in the 30th minute of exertion glucose levels in the earthed and unearthed are similar. It means that unearthed subjects need more time for glucose mobilization and consumption by the muscles and that not only epinephrine, but also contact with the Earth's potential stimulates hepatic glycogenolysis. The disposal of lactic acid in both groups is similar. Lactate production doesn't differ very much between the earthed and unearthed. Lactates are elevated in both groups in the 15th min of exercise. In general at the beginning of the exercise there is a transient rise in lactate output. With increasing duration of exercise the liver gradually shifts from a lactate- producing to a lactate- consuming state [15]. We observe diminished concentration of lactic acid after 30 minutes of exertion and next after 40 minutes of relaxation in both groups the earthed and unearthed. During the first 15 minutes, the concentration of lactates in earthed and unearthed is the highest without significant differences between these two groups [Fig.3]. Earthing can also influence acido-basal homeostasis changing conditions of the carbohydrate metabolism during the exertion. For instance increased pH can result in increased lactate accumulation but regulation of this process is multifactorial [16, 17].

We notice that the disposition to increase glucose pool during early stage of exertion under earthing for its effective utilization in training muscles in our opinion could be observed in longer duration and higher intensity of exertion.

Effect of earthing on bilirubin formation

Processes of creation and degradation of erythrocytes take place in human body in bones, circulating system, spleen and liver. The amount of red blood cells is adjusted precisely to pathological and physiological changes of environment. Total surface of erythrocytes account 3500 to 4000 m^2. The amount of hemoglobin on 1 cm^2 of erythrocytes surface is almost the same in all mammals [15]. There is correlation between maximal oxygen consumption and amount of hemoglobin circulating in blood [8]. In healthy children and young individuals there is a correlation between the blood volume, human mass, body's surface and height [9].

Hemoglobin is released out from red blood cells when their membrane rupture at the end of their span. Red cells destruction usually occurs in the spleen which is the major site of heme catabolism. The heme is the prosthetic group of several proteins and enzyme including hemoglobin, myoglobin, cytochrome C, catalase and peroxidases [18]. The first degradation step is the rupture of heme to form biliverdin. Biliverdin is then reduced to bilirubin. Bilirubin is transported to the liver by serum albumins. In the liver bilirubin is conjugated with glucuronic acid and is secreted into the bile. Erythrocytes total amount and hemoglobin concentration are in every moment expression of the state of balance between the erythrocytes production and degradation. The hemoglobin buffer is quantitatively as important as the bicarbonate buffer system [18].

Normally exercise induces heme catabolism and bilirubin creation. Plausible mechanism of increased hemolysis in exercise and thus elevated heme catabolism and bilirubin creation are oxidative stress during aerobic training. Intravascular hemolysis is one of the most emphasized mechanisms for destruction of erythrocytes during and after physical activity. Exercise induced hemolysis is cause by increased heel strike, elevated temperature and just mentioned- oxidative stress during aerobic training. Exercise induced oxidative stress may contribute to exercise-induced hemolysis in sedentary humans [19]. Swift *et al*. found that only the highest dose of exercise training significantly increases bilirubin concentration in overweight and obese postmenopausal women [20]. Elevated serum bilirubin levels are associated with decreased risk for cardiovascular diseases [21], reduced risk of stroke [22] and peripheral arterial disease [23]. Bilirubin levels below 0,7-0,8 corresponds to a greater risk of cardiovascular disease. There is the evidence that lower body fat and reductions in weight are associated with the elevated bilirubin levels [24]. Damon *et al*. revealed that high doses of exercise can increase bilirubin concentrations in obese women (mean BMI = $32 kg/m^2$) with impaired glucose metabolism [25]. Bilirubin concentration rises in exercise due to increased activity of heme-oxygnase-1- the enzyme responsible for the conversion of biliverdin to bilirubin and elevated core temperature. The earthing increases the surface charge on erythrocytes and reduces erythrocytes aggregation [6]. Grounding the body to the Earth substantially increases the zeta potentials on erythrocytes. Earthing increases bilirubin formation in subjects who have higher weight and reduces concentration of bilirubin due to reduced hemolysis in subjects with lower weight. Our results indicate that earthing modulates the metabolism of erythrocytes and adjusts it to the level of proper body mass and to needs of the training organism. Subjects from group B with lower weight who have lower oxygen consumption during earthing have concomitantly lower levels of bilirubin under earthing both in baseline as well in exercise and relaxation. These subjects with lower weight who are earthed produce less amount of bilirubin than subjects who are not earthed during exercise. On the other hand the same subjects who are earthed in group B consume less oxygen than subjects who are not earthed. Earthing can be an important factor which decreases exercise-induced hemolysis and possibly may be responsible for the reduction of oxidative stress.

Why can insignificant difference in weight in groups have such a huge impact on quite different metabolism of erythrocytes and formation of bilirubin? In our study we observe that the blood concentration of bilirubin during exercise and earthing depends on weight of subjects.

Earthing leads to increase of the negative charge density and neutralizes free radicals [26]. Human organism is a functional dielectric with the oxidation-reduction potential adjusted to time and space. Although the body produces large amounts of acid the pH of the body fluids is maintained in an alkaline state 7,4. Most of the hydrogen is formed as an end product metabolism. Most of the CO_2 is derived from oxidative metabolism. In blood, the chief H+ acceptor is HCO_3-. CO_2 and water are the most abundant end products at metabolism. Because CO_2 readily penetrates cellular membranes, H_2CO_3 is buffered by entire body. The plasma pH is 7,4 is higher than intracellular pH of erythrocyte 7,2. The major buffer capacity of the body is not in the blood, but in other tissues, principally in the muscle and in bone [17]. In aerobic organism, the ultimate acceptor of electrons derived from fuel molecules is molecular oxygen. Oxidation constitutes a loss of electrons. Reduction constitutes a gain of electrons.

In this experiment we have two electrolytic conductors perpendicular to each other; the earth and the human organism. These objects are in an external electromagnetic field. The reduction potential of the Earth transmitted with a metal conductor on human organism sets the integrity and continuity of hydrogen bonds of aqueous environment of human organism, changes redox potential of this environment. Thus the earth's potential is responsible for the elimination of potentials and reduction potential of the aqueous environment of the earthed organism leading to the synchronization and integration of metabolism in blood cells [1].

Conclusions

The earthing during exercise helps the training organism to mobilize plasma glucose for its muscular uptake and facilities more effective utilization in energetic processes. Earthing causes elevation of bilirubin concentration in a group of athletes with a higher weight and reduction in a group with a lower weight during exertion and recovery. Earthing modulates erythrocytes' metabolism and adjusts it to the level of proper body mass as a functional dielectric. Further studies are needed to reveal all metabolic mechanisms and reactions in exercise under earthing.

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