Biology of Sport, Vol. 25 N°2, 2008

EFFECT OF EXTREMELY WEAK PULSED MAGNETIC FIELD TYPE BEMER 3000 ON RATINGS OF PERCEIVED EXERTION

D. Gazurek, K. Spodaryk

Dept. of Clinical Rehabilitation, Faculty of Motor Rehabilitation, Academy of Physical Education, Cracow, Poland

Abstract. The aim of this study was to examine whether is an influence of the exposition on different inductions of magnetic fields on rating of perceived exertion during 10 min long standardised physical cycloergometer exercise. The investigation was performed in 40 healthy, non-smoking, fit men, mean age 20±2. The participants were randomly attributed to 4 groups, each including 10 subjects. The first one (group E_{18}) consisted of subjects exposed to the magnetic field with the intensity of 18 μT, the second one (group E_{64}) exposed to the magnetic field with the intensity of 64 μT. Two control groups were formed to accompany these exposed to the magnetic field. In these placebo groups (S-T) subjects were not exposed to the magnetic field (so called false therapy, „sham treatment"). The study consisted of 4 steps: pilot study, the first endurance test, exposure to the magnetic field, the second endurance test. The aim of the pilot study was to define subjective feelings of the participant during the effort, his reaction to the effort and also practical familiarization with the character and rules of the endurance test and Borg scale interpretation during 10 min of endurance cycloergometer test. The first endurance test was performed two days after the pilot study with the same rules and its goal was to measure the level of tiredness according to the Borg scale during 10 min long standardised physical effort. The second endurance test was performed according to the same rules as the first one and its goal was to analyse the effect of 20 exposures to the magnetic field with the intensity of 18 and 64 μT repeated daily on the perception of tiredness increase as expressed in the Borg scale when performing 10 min long standardised physical effort. In subjects exposed to 18 μT magnetic field neither changes in the perception of fatigue nor changes in the heart rate at particular levels of the Borg scale have been observed. When compared with both control and placebo group subjects exposed to 64 μT strong magnetic field exhibited statistically significant increase in the period of attaining consecutive levels of fatigue as measured in the Borg scale. Results of the present study demonstrated beneficial influence of the magnetic field with 64 μT intensity on changes in the perception of fatigue during physical workload.

(Biol.Sport 25:147-165, 2008)

Key words: Magnetic field - Exercise - Rating of perceived exertion

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Reprint request to: Dr Dorota Gazurek, Dept. of Clinical Rehabilitation, Faculty of Motor Rehabilitation, Academy of Physical Education, Al. Jana Pawła II 78, 31-571 Cracow, Poland; E-mail: sinka_g@poczta.onet.pl

Introduction

Early studies showed that when a subject's muscles appeared to be nearly exhausted, verbal encouragement, shouting or even direct electrical stimulation of the muscle could increase the strength of the muscle concentration. These studies suggest that the limits of performance in exhausted exercise may to a great extent be psychological. The precise mechanism underlying such CNS fatigue are not fully understood. Subjective correlates of fatigue are complex, reflecting the integration of many discrete sensations having different physiological origins. The adjectives reflect various states of mood, somatic discomfort, and arousal. They are classified according to three broad clusters: fatigue, task aversion, and motivation. The adjectives that constitute the fatigue cluster are directly associated with physiological limitations to exercise performance. Each adjective was rated separately prior to and at the end of cycle ergometer endurance tests performed at an intensity about 65%VO_{2max}.. When measured at selected time points during submaximal (80%VO_2max) cycle ergometer exercise, subjective symptoms of fatigue and exertional intolerance in the legs (i.e., aches, cramps, pain, fatigue, muscular and articular heaviness) and cardiorespiratory system (i.e., sensations of dyspnea) were shown to be strong predictors of submaximal endurance performance. It was concluded that subjective symptoms arising from muscles, joints, and the cardiorespiratory system operate in consort with physiological processes to set the upper limits of endurance performance [8].

Perceived exertion (PE) can be defined as the act of detecting and interpreting sensations arising from the body during physical exercise. The 15-graded scale is referred to as the Borg scale or the ratings perceived exertion (RPE) scale. Since its development, the 15-graded scale has been used in a variety of experimental situations. The following experimental uses were noted: walking and running, physical training, concentric and eccentric exercise, effect of muscle mass, temperature, chronic obstructive pulmonary disease, altitude, psychological factors, menstruation, sleep deprivation, gender, circadian rhythms, occupational tasks, aging and growth. In practice RPE are often use in the clinical setting to assess exercise tolerance and to prescribe and regulate therapeutic training intensity. RPE are frequently used as an adjunct to standard physiological and clinical responses during a graded exercise testing widely applied in clinical, research, and sport settings. The linear relation between RPE and such variables as heart rate, oxygen uptake, and power output is particularly important when measures are to be obtained during a submaximal test and used to predict maximal aerobic power. The role of RPE in exercise prescription is significant. Exercise training in athletic, recreational, and therapeutic settings should follow a carefully developed and individualized prescription of optimal performance benefits are to be realized. The prescription of exercise intensity is based on physiological (maximal oxygen consumption VO_2max, heart rate HR, ventilatory V_E), clinical (ECG abnormalities, anginal pain, blood pressure abnormalities) and perceptual (RPE) responses to a graded exercise test. RPE can be used for both the prescription and regulation of exercise intensity.

As far as we know, there are no reports in the literature concerning the influence of physical modalities on ratings of perceived exertion. Frequently some physicological intervention are use after exercise and physical training as biological restoration. For more than four years the extremely weak electromagnetic field is used. This is physiotherapeutical modality in which the stimulation is mediated via a sequence of extremely low frequent, wide band pulsed weak electromagnetic fields, each pulse being characterized by the formula $y=k(x)_* \ x^a{}_* \ e^{\sin(x^\wedge b)}/c+d$, [e.g. k(x)=1, x[0,4]; a=b=3; c=50; d=0] – so-called BEMER 3000® signal (Fig. 1).

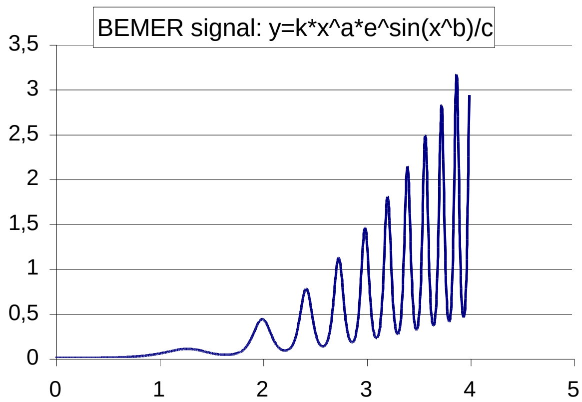

Fig. 1
Single spectral wide banded BEMER type pulse applied during electromagnetic stimulation. K=1; a=b=3; c=50; ordinate: magnetic flux; abscissa: time (each arbitrary units); pulse duration 33.3 ms; pulse repetition 30 HZ

There is considerable interest in the therapeutic use of BEMER magnetic field because the beneficial results and the increased clinical acceptance for the therapy of pain, various etiologies, wound healing and inflammation of joints and muscle achieved by various non-invasive applications of pulsed, weak electromagnetic fields has been reported [10].

Repeated exposition on extremely weak pulsed electromagnetic field (BEMER 3000) alter physiologic responses to exercise as delayed onset of muscle soreness [28]. Thus, long term exposition on this kind of physical modality may be a responsible for lower perception of exertion after the physical exercise to exhaustion. The purpose of the present study, was to examine whether is an interaction between length of recovery between repeated exercise bouts and the exposition on different inductions of magnetic fields.

Materials and Methods

Subjects: The studied group consisted of 40 healthy, non-smoking, fit men 19-22 years old, weighing 74-88 kg. They all were students of the Academy of Physical Education in Cracow. Before the experiment all participants were instructed as to its goals, character and time frame. Volunteers were familiarized with the method of defining parameters characteristic for the studies on the intensification of tiredness symptoms of and each participant was given a model of 15 levels of the Borg scale. Before the experiment and during it they discontinued performing strenuous exercises and using stimulants (caffeine, alcohol, cigarettes). They all signed the consent to take part in the experiment.

Experiment design The study consisted of 4 steps: pilot study, the first endurance test, exposure to the magnetic field, the second endurance test.

The aim of the *pilot study* was to define subjective feelings of the participant during the effort, his reaction to the effort and also practical familiarization with the character and rules of the endurance test and Borg scale interpretation. The pilot study consisted of 10 min long endurance test performed on the Monark type cycloergometer. Each participant 5 min before starting the test had heart rate (HR) measured. On „start" 10-min long standardised physical effort began, with constant load of 2.5 kg, force kept at 150 W and pedalling speed 60 rotations/min. Keeping the constant value of work was possible due to the control of the number of cycles exhibited on the cycloergometer monitor and a metronome set at the appropriate pace. During the whole time of the test subjects reported the level of their tiredness according to the 15-levels of the Borg tiredness scale. With every increase in that value HR was noted and also time when it occurred reported. HR was measured continuously using the Sport-Tester (Polar). Just after the test and after 5 min of rest HR was also measured.

The first endurance test was performed two days after the pilot study with the same rules and its goal was to measure the level of tiredness according to the Borg scale during 10 min long standardised physical effort.

Before the *exposure to the magnetic field* of the BEMER type participants were randomly attributed to 4 groups, each including 10 subjects. The first one (group E_{18}) consisted of subjects exposed to the magnetic field with the intensity of 18 μT, the second one (E_{64}) exposed to the magnetic field with the intensity of 64 μT. Two control groups were formed to accompany these exposed to the magnetic field. In these placebo groups (S-T) subjects were not exposed to the magnetic field (so called false therapy, „sham treatment"). However, all subject were informed that they were exposed to the magnetic field. Twelve min long exposure to the magnetic field with the intensity of 18 or 64 μT or false therapy was performed in supine position every day for 20 days between 14 and 17 PM. During 20 days of experiment HR in each subject before and just after exposure to the magnetic field was noted.

Electromagnetic stimulation was performed by the application of the BEMER 3000 (Innomed International AG, FL-Triesen). It consists of a signal generator unit (with manual adjusting time of exposition an intensity) and a mattress containing 6 (four circular, □ 25 cm and 2 oval 25/40) flat electrical coils as stimulus applicators. The stimulation was mediated via a sequence of extremely low frequent, wide band pulsed weak electromagnetic field. The mean magnetic flux intensity of the signal at the surface of the mattress (0.7 x 1.7 m^2) was either 18 or 64 μT. Its 3D spatial distribution is reflected in Fig. 2. The electrical components are to be determined by its 1^{st} derivative according to the Induction law of the Maxwell Equations. The study was performed using BEMER 3000 apparatus built of the mattress 70x170 cm for the whole body therapy and steering device. The mean magnetic flux intensity of the signal at the surface of the mattress was either 18 or 64 μT.

The second endurance test was performed according to the same rules as the first one and its goal was to analyse the effect of 20 exposures to the magnetic field with the intensity of 18 and 64 μT repeated daily on the perception of tiredness increase as expressed in the Borg scale when performing 10 min long standardised physical effort.

The descriptive analysis of the results was applied to determine whether there were any differences between the groups.

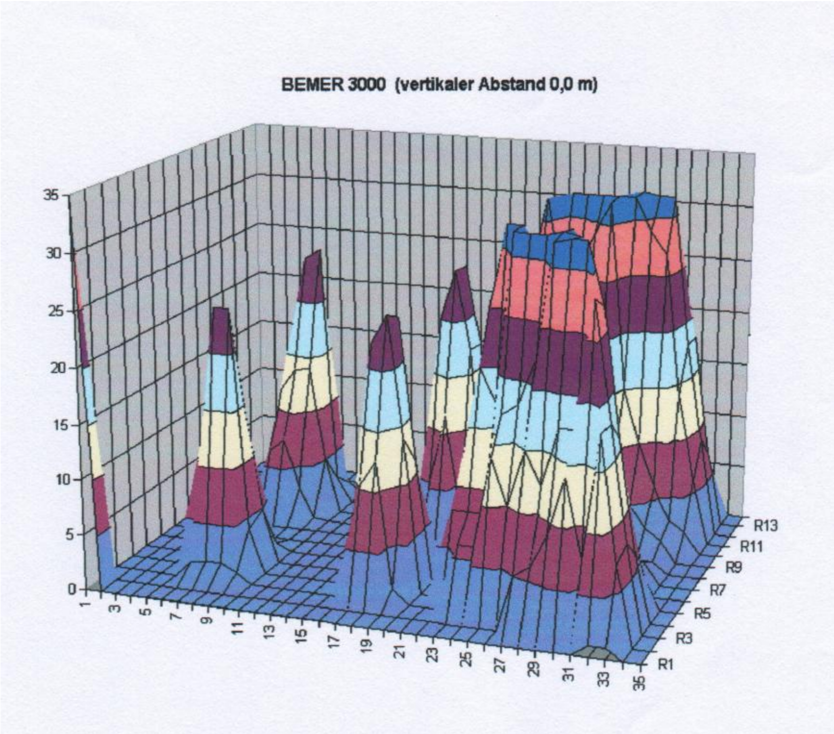

Fig. 2
3D spatial distribution of magnetic flux intensity (arbitrary units) directly on the surface of the mattress; the field, deriving from the six flat coils is strongly inhomogeneous; the peak on the down left corner is due to norming; head position left

Results

After 20 days of repeated exposure to the magnetic field with mean magnetic flux intensity of the signal at the surface of the mattress 18 μT (group E18) small differences in the mean values of HR among the studied groups have been observed (Table 1). In the first group exposed for the magnetic field for 12 min all subjects responded with a decrease in HR as compared to their initial HR. In the second, placebo group, HR history was different. In 8 subjects there was a slight increase, in 1 a decrease and in another one there was no change as compared to the initial values.

Table 1
Evolution of mean values of HR in the studied subjects before and after 20 days of exposure and sham exposure to the 18 µT magnetic field (group E_{18})

Subject	Magnetic field + exposure -sham exposure	HR before therapy	HR after therapy	ΔHR
1	+	82	76	6 ↓
2	+	65	64	1 ↓
3	+	72	70	2 ↓
4	+	72	71	1 ↓
5	+	70	68	2 ↓
6	+	60	58	2 ↓
7	+	75	69	6 ↓
8	+	61	57	4 ↓
9	+	66	64	2 ↓
10	+	60	58	2 ↓
1	-	70	68	2 ↓
2	-	82	78	4 ↓
3	-	56	55	1 ↓
4	-	83	79	4 ↓
5	-	69	65	4 ↓
6	-	71	70	1 ↓
7	-	77	77	=
8	-	69	68	1 ↓
9	-	58	60	2 ↑
10	-	72	70	2 ↓

↓-the decrease in the mean value of HR as compared to the mean HR before exposure;
↑-the increase in the mean value of HR as compared to the mean HR before exposure;
= - mean values of HR before and after exposure to the magnetic field are equal

After 20 days of repeated exposure to the magnetic field with mean magnetic flux intensity of the signal at the surface of the mattress 64 µT (group E64) clear differences in the mean values of HR between the subjects from the two groups have been observed (Table 2). In the first group exposed for 12 min to the magnetic field in all subjects a decrease in HR as compared to the HR before exposure has been observed. From the second placebo group in 6 subjects there was an increase in HR, in 3 a decrease and in 1 there was no change in HR as compared to the initial HR values.

Table 2
Evolution of mean values of HR in the studied subjects before and after 20 days of exposure and sham exposure to the 64 μT magnetic field (group E64)

Subject	Magnetic field	HR before therapy	HR after therapy	ΔHR
1	+	77	70	7 ↓
2	+	74	65	9 ↓
3	+	80	75	5 ↓
4	+	68	61	7 ↓
5	+	84	74	10 ↓
6	+	60	57	3 ↓
7	+	71	70	1 ↓
8	+	77	65	12 ↓
9	+	68	64	4 ↓
10	+	62	53	9 ↓
1	-	72	71	1 ↓
2	-	65	66	1 ↑
3	-	58	59	1 ↑
4	-	68	69	1 ↑
5	-	64	66	6 ↑
6	-	52	52	=
7	-	73	72	1 ↓
8	-	65	67	2 ↑
9	-	54	55	1 ↑
10	-	77	76	1 ↓

↓-the decrease in the mean value of HR as compared to the mean HR before exposure;
↑-the increase in the mean value of HR as compared to the mean HR before exposure;
=-mean values of HR before and after exposure to the magnetic field are equal

After 20 days of exposition on the 18 μT magnetic field (group E18) a tendency towards the prolongation of reaching consecutive stages of tiredness as measured in the Borg scale when performing the II endurance test, when compared with the results obtained before therapy with the magnetic field when performing the I endurance test (Tables 3 and 4) have been observed. These tendencies were similar in both studied groups. In the group subjected to therapy for 9 subjects the time of reaching consecutive stages of tiredness was longer while for 1 shorter. The situation was similar in the placebo group where such ratio was 8:2.

Table 3
Changes in RPE during the time of performing the endurance test before and after 20 days long exposure to the 18 μT magnetic field (group E18)

Subject	RPE I	Time of reaching RPE I	HR with a given value of RPE I	RPE II	Time of reaching RPE II	HR with a given value of RPE II
1	7	0.40	117	7	1.00	127
	8	1.41	134	9	2.25	138
	11	3.10	145	11	4.38	154
	13	5.15	155	13	6.30	164
	15	8.20	159	15	9.20	173
2	7	3.40	163	7	4.15	171
	9	6.30	179	9	7.20	182
3	7	2.20	161	7	2.50	150
	9	4.45	172	9	6.00	154
	11	7.10	177	11	8.00	167
	13	8.35	180			
4	7	3.00	142	7	2.40	145
	9	4.55	152	9	4.50	155
	11	7.30	156			
5	7	1.15	128	7	1.30	119
	9	2.15	132	9	3.10	133
	11	6.15	143	11	8.15	143
	13	8.45	148			
6	7	3.20	117	7	3.10	107
	9	4.50	118	9	5.10	110
	11	6.50	122	11	8.14	115
	13	9.26	127			

7	7	3.11	120	7	3.02	118
	9	5.13	125	9	6.14	127
	11	7.02	127	11	7.20	130
8	9	3.23	126	9	4.20	130
	11	5.45	134	11	6.55	138
	13	8.50	140			
9	7	2.46	135	7	3.25	138
	9	5.24	146	9	6.37	147
10	9	3.47	130	9	3.56	128
	11	4.50	137	11	6.34	139
	13	6.24	145	13	7.23	147
	15	9.23	148			

RPE I - values of RPE reached when performing the I endurance test;
RPE II - values of RPE reached when performing the II endurance test

Table 4
Changes in RPE during the performance of the endurance test before and after 20 days of repeated sham exposure to the 18 μT magnetic field (group S-T E18)

Subject	RPE I	Time of reaching RPE I	HR with a given value of RPE I	RPE II	Time of reaching RPE II	HR with a given value of RPE II
11	7	2.20	137	7	2.30	133
	9	4.15	134	9	5.15	140
	11	6.00	140	11	8.10	149
	13	8.30	144			
12	7	0.55	139	7	1.15	140
	9	2.30	155	9	4.05	161
	11	4.40	160	11	6.50	165
	13	8.00	167	13	9.30	170
13	7	2.00	126	7	3.30	124
	9	5.10	134	9	6.20	132
14	7	0.40	121	7	1.00	125
	9	2.40	136	9	3.02	141
	11	4.00	157	11	4.45	146
	13	6.00	164	13	7.06	146
	15	8.50	168	15	9.40	153

15	7	3.12	121	7	4.50	129
	9	6.25	130	9	6.50	132
	11	7.30	135	11	8.10	137
16	7	0.56	125	7	1.23	122
	9	3.34	145	9	3.30	135
	11	4.56	157	11	4.23	150
17	7	3.54	134	7	3.50	136
	9	6.41	145			
18	9	4.45	134	9	4.50	136
	11	6.22	147	11	7.00	150
	13	9.18	150	13	9.20	152
19	7	2.12	122	7	2.30	125
	9	4.50	146	9	5.10	148
20	7	0.59	119	7	2.11	120
	9	3.46	129	9	3.37	127
	11	6.33	139			

RPE I - values of RPE reached when performing the I endurance test;
RPE II - values of RPE reached when performing the II endurance test

Together with the prolongation of the time of attaining consecutive stages of tiredness changes in the values of HR attributed to the levels of the Borg scale were noted. In both groups HR values were similar, ca 55% higher for given tiredness levels reached later then in the I endurance test time.

After 20 days of therapy with the 64 μT magnetic field (group E_{64}) clear tendency of prolongation of the time of attaining consecutive levels of tiredness as measured in the Borg scale when performing the II endurance test, when compared with the results obtained before therapy when performing the I endurance test has been observed (Tables 5 and 6). These tendencies were different in the two studied groups. In the group exposed to the magnetic field the time of attaining consecutive levels of tiredness was longer for 9 subjects and shorter for 1. The situation was different in the placebo group where the increase in that time was observed in two subjects only. In the remaining studied subjects the time of attaining consecutive stages of tiredness was shorter when compared to the results obtained when performing the I endurance test.

Table 5
Changes in RPE when performing the endurance test before and after 20 days of exposure to the magnetic field 64 μT (E64)

Subject	RPE I	Time of reaching RPE I	HR with a given value of RPE I	RPE II	Time of reaching RPE II	HR with a given value of RPE II
1	7	2.34	135	7	3.35	136
	9	5.45	147	9	6.30	150
2	7	0.56	120	7	1.22	121
	9	3.44	138	9	4.50	140
	11	7.00	149	11	7.51	150
3	7	2.22	123	7	3.03	130
	9	3.24	135	9	3.56	141
	11	5.47	138	11	7.21	140
	13	9.11	142			
4	9	4.12	119	9	5.05	126
	11	6.34	128			
5	7	0.56	124	7	2.22	127
	9	3.33	144	9	3.50	140
6	9	3.54	122	9	4.00	125
	11	4.57	135	11	5.55	140
	13	7.22	148	13	8.01	149
	15	9.45	150			
7	7	2.16	118	7	2.17	115
	9	5.23	125	9	6.01	127
8	9	4.50	136	9	5.11	135
	11	7.11	140	11	7.54	138
9	7	0.45	122	7	1.11	120
	9	2.44	132	9	2.13	121
	11	5.21	144	11	6.38	139
	13	7.18	146	13	8.09	143
	15	9.00	151			
10	9	2.12	132	9	2.09	128
	11	6.22	149	11	6.13	140

RPE I - values of RPE reached when performing the I endurance test;
RPE II - values of RPE reached when performing the II endurance test

Table 6
Changes in RPE when performing the endurance test before and after 20 days of sham exposure to the 64 μT magnetic field (group S-T E64)

Subject	RPE I	Time of reaching RPE I	HR with a given value of RPE I	RPE II	Time of reaching RPE II	HR with a given value of RPE II
11	7	1.12	122	7	1.15	120
	9	5.33	132	9	5.30	129
12	7	1.33	118	7	1.30	120
	9	3.07	126	9	3.05	125
	11	5.24	144	11	5.30	140
	13	8.37	152	13	8.20	149
13	7	2.25	121	7	2.20	128
	9	6.47	148	9	6.13	146
	11	8.33	151	11	8.20	149
14	7	1.22	112	7	1.11	117
	9	5.19	133	9	5.10	135
	11	7.34	136	11	7.30	139
15	7	2.34	136	7	2.02	135
	9	7.21	145	9	6.58	143
16	9	3.33	127	9	4.00	122
	11	4.14	145	11	4.20	149
	13	6.56	148	13	6.00	149
	15	9.34	155	15	9.12	151
17	7	0.58	130	7	1.00	132
	9	2.55	145	9	2.30	143
	11	7.59	160	11	6.55	157
18	9	3.25	149	9	3.30	147
	11	6.57	162	11	6.40	160
	13	9.19	165	13	9.10	163
19	7	2.46	120	7	2.30	121
	9	4.00	137	9	4.03	135
	11	7.33	146	11	7.12	148
20	7	0.57	147	7	1.00	143
	9	3.38	156	9	3.43	154
	11	5.25	160	11	5.30	158
	13	7.45	162	13	7.50	160
	15	9.22	164	15	9.30	162

RPE I - values of RPE reached when performing the I endurance test;
RPE II **-** values of RPE reached when performing the II endurance test

Changes in values of HR attributed to the levels of tiredness as measured in the Borg scale during the II endurance test also had different character within the studied groups. In the first one for 6 subjects an increase in HR values attributed consecutively to the levels of tiredness as measured in Borg scale, for 3 a decrease and for 1 initial increase followed by a decrease, when compared to the results obtained before therapy with the magnetic field when performing the I endurance test have been observed. The situation was reverse in the placebo group. The increase in HR was noted only in 1 subject, a decrease in 5 while 4 reacted with an increase followed by a decrease.

Discussion

The aim of the study was to determine the effect of daily, 20 min long exposure to the 18 μT or 64 μT magnetic field on the ratings of perceived exertion (RPE) after 10 min long standardised physical effort. When compared with both control and placebo group subjects exposed to 64 μT magnetic field exhibited statistically significant increase in the period of attaining consecutive levels of fatigue as measured in the Borg scale. At the same time statistically significant increase in the heart rate during physical training at a given level of the Borg scale was noted. On the other hand, when compared to placebo and control group in tested subjects resting heart rate showed a tendency to decrease in the consecutive days of exposure. In subjects exposed to 18 μT magnetic field neither changes in the perception of fatigue nor changes in the heart rate at particular levels of the Borg scale have been observed. However, in this group like in the one exposed to the 64 μT magnetic field a tendency to a decrease in the heart rate in resting conditions has been observed.

Many physiological factors have been thought to mediate the intensity of RPE. The physiological processes that are thought to function as a mediators for the respiratory-metabolic signal of exertion include drive (V_E), oxygen consumption (VO_2), carbon dioxide exertion (VCO_2), heart rate (HR), and blood pressure [7,9,20]. Experimental and clinical evidence strongly support ventilatory function as a physiological mediator for the respiratory-metabolic signal of exertion. Robertson *et al.* [24] used autologous red blood cell (RBC) infusion to perturb V_E (ventilatory drive) during cycle ergometer exercise. The erythrocythemia that occurs with infusion increases arterial oxygen content and consequently reduces V_E for a constant submaximal power output or total body VO_2. The purpose was to determine if RPE-Chest (RPE-C) changed in parallel with the post-reinfusion attenuation of V_E. Pulmonary decreased from pre to post-reinfusion at the power output equivalent to 45% VO_{2max}, while RPE-C was unaffected by artificial expansion of RBC mass. Both V_E and RPE-C were lower during the post-reinfusion than during the pre-infusion suggesting a casual link between the two processes.

The demand for breathing is regulated in large part by metabolic requirements for tissue oxidation (VO_2) and carbon dioxide exertion (VCO_2). These two determinants of pulmonary gas exchange serve as physiological mediators for the perceptual signals associated with VO_2 are mediated by the ventilatory drive required to support aerobic metabolism. As ventilatory drive intensifies in response to a greater aerobic energy requirement, increase inspiratory muscle tension is consciously perceived as a signal of respiratory- metabolic exertion correlation coefficients for the relation between VO_2 and RPE range from r=0.76 to r=0.97 for both intermittent and continuous arm and leg exercise [5,21]. In general, experimental evidence indicates that for most exercise conditions the relative metabolic rate functions as a mediator for respiratory-metabolic signals of exertion. The functional link between %VO_2max and RPE has important implications for perceptually regulated exercise prescriptions as well as laboratory assessment of exercise performance. Also ventilatory exertion of CO_2 during exercise serves as a signal mediator for respiratory-metabolic perceptions of exertion [25]. Heart rate does not appear to function as a physiological mediator for respiratory-metabolic signals of exertion [24] also the concept of a finite metabolic threshold for the onset of the respiratory-metabolic signal of exertion remains unclear.

The intensity of peripheral exertional perceptions has been linked to acidotic shifts in blood and to appearance of lactic acid in blood and muscle. Metabolic acidosis appears to mediate the intensity of exertional perceptions in skeletal muscle during high - intensity dynamic exercise. Experimental evidence indicates that blood pH is more important than blood lactic acid concentration [7,12] in mediating peripheral perceptual signals. However, sufficient evidence is not available to draw conclusions regarding the possible role of muscle lacid acid in mediating the intensity of perceived exertion during dynamic exercise [6,18,30].

Then intensity of peripheral perceptual signals appears to be more intense when the skeletal muscle involved in the exercise has a comparatively high concentration of fast-twitch fibers. The contractile properties of slow- and fast- twitch muscle fibers may differentially mediate the intensity of peripheral exertional perceptions [18]. Blood flow to exercising muscle determines the availability of energy substrates for exercise metabolism. Inadequate perfusion of tissue limits metabolism, inducting fatigue and intensifying the peripheral perceptual signal.

During prolongated submaximal exercise, the blood levels of glucose and free fatty acid (FFA) are thought to mediate the intensity of exertional perceptions [3]. However under some exercise conditions the blood levels of glucose and FFA change as approximate reciprocals of one another. The level of blood glucose appears to be important physiological mediator for peripheral exertional perceptions. As blood glucose is depleted during the middle to larger stages of submaximal endurance exercise, muscle fatigues, causing an increase in perceptual signal strength. In contrast, plasma FFA and glycerol are not influential in determining the intensity of perceived exertion [16].

Physiological mediators that are not directly linked to peripheral or respiratory metabolic perceptual signals are termed nonspecific. Hormonal regulation is an nonspecific mediator of perceived exertion. Evidence supporting that catecholamines (CATs), as hormonal mediators for perceived exertion is suggestive but not totally consistent. During multistage treadmill testing, central RPE (RPE-C) correlates positively with both norepinephrine (r=0.63) and epinephrine (r=0.54) [27]. These data suggest, that CATs productions may mediate the intensity of perceived exertion. In contrast other investigation have shown that the intensity of perceived exertion is independent of CATs level [31]. The role of beta- endorphins as a mediator of RPE is only suggestive and has received very little experimental attention. Some authors reported that RPE did not correlate with exercise- induced increases in beta-endorphins [4,13].

Exertional perceptions during dynamic exercise intensify as ambient temperature increases. This suggests that perceived intensity of exertion is influenced by physiological processes that regulate body temperature during exercise. Body core temperature (Tc) and RPE increase as metabolic heat production increases during dynamic muscle contractions, but there is no evidence supporting casual relation between physiological factors that regulate Tc and the intensity of exertional perceptions. The correlation is consistently low and not statistically significant [21]. No correspondence is noted between Tc and RPE during exercise involving hot [22,29] neutral and cold environments; arm and leg ergometry [17]; eccentric muscle training and thermal acclimation [22]. Pivarnik *et al.* found Tc did not differ between exercise trials in hot (33^{o}C) and thermoneutral (23^{o}C) environments, while the overall rating of perceived exertion was higher under heat stress. These data indicate that Tc does not influence the intensity of exertional sensations during dynamic exercise. Also correlational evidence that links skin temperature (Ts) with intensity of exertional perceptions during exercise in hot and cold is both limited. Using a stepwise regression analysis, Noble *et al.* [17] found that Ts accounted for a significant amount of variance in RPE for the overall body under hot environmental conditions. In contrast others [29] did not find a significant correlation between (Ts) and RPE during leg and arm exercise in cold water. Experimental evidence derived from investigations in which environmental temperature has been manipulated generally support (Ts) as a mediator of exertional perceptions under both hot and cold conditions. Under thermal stress, skin temperature mediated the intensity of the nonspecific exertional signal. Skin temperature responses to thermal stress are influenced by sweat production and both blood flow and volume, therefore processes that regulate sweating and peripheral vascular resistance may also mediate the perceived intensity of exertion in abnormally hot or cold ambient temperatures [23].

Psychological factors, both situational and dispositional play a role in the setting of perceptual self-reports. This classification reflects the setting-dependent influence of psychological processes in shaping perceptual responsiveness during exercise. That is, dispositional factor are enduring traits that mediate perceptual signals in a consistent and predictable manner during most performance settings. Examples of dispositial mediators are stimulus intensity modulation, locus of control, cognitive style, self-efficacy, sex-role orientation, personality. Situational factor can affect the perceptions of exertion. Such factors include hypnotic suggestion [13], expected duration of exercise, expected performance level, outcome presentation, self-presentation, and attentional focus [2]. The various dispositional and situational psychological factors either directly mediate the intensity of exertional perceptions or else function as components of perceptual cognitive reference filter that systematically modulates the intensity of the exertional signal according to individual differences in personality, mood state, and symptomatic responses.

A number of factors involving test methods, individual characteristic, and environmental conditions can influence perceptual responses during exercise evaluation. As an example, test intensity (e.g, walking speed or pedal frequency) [15], format, and mode should be selected in accordance with subject’s perceptual preference. Also muscle mass [11], age [14], gender, testing condition (e.g, sleep deprivation) exercise mode and the ventilatory threshold all exert a systematic influence on RPE during exercise testing.

Despite numerous observations supporting the notion of the influence of biological and environmental factors on changes in RPE cited above, in the available literature there is no information on physical factors as possible modificators of RPE. On the other hand, various physiotherpeutical modalities are applied in broadly understood fitness restoration, among others in professional sportsmen. Their influence on changes in the circulatory, nervous and endocrine systems is well documented. However, to our knowledge there are no reports on their influence on RPE. Results of the present study demonstrated beneficial influence of the magnetic field with 64 μT intensity on changes in the perception of fatigue during physical workload. Therefore further studies in this field seem to be justified.

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Accepted for publication 8.09.2003