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Influence of *Lepidium meyenii* on stress induced by walking on a treadmill

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Abstract

Background. High intensity physical exertion is a stress for the body; Lepidium meyenii (LM) is known for its antistress effects.

Aims. This study aimed to highlight phytotherapic modulation, under the action of a Lepidium meyenii product (LM; LMP), on anxiety (A), glycemia (G) and salivary pH (SpH), in physical stress caused by walking very fast on the treadmill, in sedentary subjects.

Methods. 24 healthy male volunteers were randomized to: a control group (C=8), without treatment; a group who received LMP 12 days (LM1=8); a group who received LMP 21 days (LM2=8). Stress model: walking very fast on the treadmill. Analyzed indicators: anxiety (A), glycemia (G) and salivary pH (SpH). Determinations: before LM treatment (T1), 15 minutes (T2) before, 30 minutes (T3) and 4 hours (T4) after the physical effort. The results obtained were analyzed using the SPSS statistical package.

Results. For C, compared to T1, the most significant were: increases for A (T2), G (T3); decrease for SpH (T3). In LM1 and LM2, values were significantly: low for A (T2), G (T3); high for SpH (T3). LM2 impact was greater than LM1. LM1/ LM2 influence was more important on A.

Conclusions. 1) Dynamic developments of A, G, SpH were different for C, LM1/ LM2. 2) LM significantly reduced A/ G, increased SpH, with a more important influence on A. 3) LM2 effect was more intense than LM1. 4) We suggest LM may be useful in A, G, SpH modulation, in stress caused by walking very fast on the treadmill, in sedentary people, but further research is needed.

Keywords: stress, Lepidium meyenii, exercise, stress, anxiety, glycemia, salivary pH.

Introduction

Short-term physical exertion can be an important stress factor, as evidenced by increased cortisol (Cosio-Lima, 2012) and state anxiety, immediately pre- and post- exertion (Hermann et al., 2019; Jurcău & Jurcău, 2018), or involves other psychological factors (Monea et al., 2011; Ormenișan, 2008a; Ormenișan, 2008b). In addition, intense physical exertion can induce increased blood sugar (Jurcău et al., 2017; Keselman et al., 2017). On the other hand, modulation of the stress induced by physical exertion, especially by intense effort, has been a continuous concern for research in the field of sport, plant extracts and nutritional supplements. Thus, adaptogens (Panossian et al., 2018) and plants with an adaptogenic role represent an important resource for modulating stress in general and physical exertion stress, in particular. In this sense, there are studies that have shown the modulation of physical stress with Eleutherococcus senticosus (Kimura & Sumiyoshi, 2004), Rhodiola rosea (Huang et al., 2009), Schisandra chinensis (Panossian, 2013; Jurcău et al., 2019) and Ginseng (Yang et al., 2018; Jurcău et al., 2018).

Lepidium meyenii (LM or Maca) is a plant recognized for its adaptogenic qualities. The interest in LM has increased in many parts of the world, and since 2005 this has been considered one of the seven representative Peruvian products (Gonzales et al., 2009). LM is a plant that grows at over 4000 meters altitude in the Central Andes of Peru and has different varieties depending on the color of the hypocotyl (Gonzales et al., 2014). It was found that

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differences between the biological properties of the three types of LM depend on differences in the cultivation soil (Zhao et al., 2012); on the other hand, all these varieties are present in the same soil (Tello et al., 1992). Thus, red maca has beneficial effects on mood, energy; black maca reduces blood sugar levels; both varieties produce similar responses on mood and health related quality of life score and improve quality of life parameters (Gonzales-Arimborgo et al., 2016). Maca contains many proteins, amino acids, fats and vitamins (Dini et al., 1994), secondary metabolites and other components (Cui et al., 2003).

LM is known to be an extremely effective remedy for the treatment of impotence (Qureshi et al., 2017) and a natural stimulant for improving sexual dysfunctions (Stone et al., 2009) in postmenopausal women, independent of estrogen and androgen activity (Brooks et al., 2008). It can also be used, as a dietary supplement, in the prevention and treatment of atherogenic lipoprotein, liver steatosis, antioxidative stress and impaired glucose tolerance (Vecera et al., 2007). Following treatment with black maca, in diabetic rats, thiobarbituric acid reactive substances and carbonylated proteins were reduced; therefore, lipid oxidation was also diminished and also increased the activity of superoxide dismutase and antioxidants of catalase (Qiu et al., 2016). In vitro, Maca increased cell viability and reduced cytotoxicity against oxidative stress, suggesting a neurobiological effect (Rodríguez-Huamán et al., 2017). In cells pre-treated with Maca extract, SOD activity increased, so that LM exhibited an antioxidant effect, by inhibiting the activity of free radicals, thus having a neuroprotective effect (Masoudi et al., 2014).

Administration of Maca 1% in the diet of hypertriglyceridemic animals led to an improvement in lipid profile and an increase in glucose tolerance (Vecera et al., 2007). In another rat study, in which diabetes was induced by administration of streptozotocin, administration of yellow maca resulted in decreased blood sugar and insulin levels (Rodrigo et al., 2011). In a male rat experiment in which diabetes was induced by administration of streptozotocin, administration of a black maca hydroalcoholic extract reduced blood glucose by 50% (Gonzales et al., 2013).

LM is also consumed as a sports supplement by endurance athletes (Stone al., 2009). Thus, macamides, the main active components contained in Maca, determine the alleviation of physical fatigue by alleviating lesions of skeletal muscle and myocardium during exercise (Zheng et al., 2019). Following administration of a soluble lipid extract of yellow LM for three weeks, physical resistance increased by 41% compared to the control value, and the administration of a hydroalcoholic extract of black maca led to an increase in physical resistance of over 500% compared to the control (Choi et al., 2012). The administration of maca extract for 14 days to cyclists, participants in a 40 km race, significantly and quickly improved the performance time (Stone et al., 2009). In another study, the administration of a fresh maca concentrate, 500 mg daily for 60 days, to ten professional football players led to an increase in oxygen consumption and physical resistance (Ronceros et al., 2005).

After higher doses of Maca treatment, in stressed mice, serum corticosterone levels were reduced (Ai et al., 2014). In addition, LM reduces psychological symptoms, including depression, anxiety (Brooks et al., 2008), and stress (Qureshi et al., 2017).

Objectives

This study aimed to highlight phytotherapeutic modulation, under the action of Lepidium meyenii (LM) product (LMP), on anxiety (A), glycemia (G) and salivary pH (SpH), in physical stress caused by walking very fast on the treadmill, in sedentary subjects.

Material and methods

Research protocol

a) Period and place of the research

An informed consent was obtained from each participant, according to the Declaration of Helsinki. The study was carried out in the 103 Family Medicine Cabinet in Cluj-Napoca, in December 2018.

b) Subjects and groups

A number of 24 volunteer healthy men were randomized to: the control group (C=8), without treatment; a group that received LMP for 12 days (LM1=8); a group receiving LMP for 21 days (LM2=8). The participants' average age was: 29.1±3 (C), 30.2±3 (LM1), 31.4±4 (LM2). The volunteer subjects came from several fitness centers near the family medicine office, and at the family medicine office the work place was set up, under medical supervision. The treadmill was borrowed from one of these fitness centers. All participants were asked not to smoke, not to consume coffee, alcohol, and not to use any medication or antioxidant the day before and during the physical effort. The study did not include persons with mental disorders, toxic addiction and cortisone therapies.

c) Tests applied

1) Study design

Before physical testing, all participants had a 4-min muscle heating session, on the treadmill (Technogym Myrun) adjusted to 30 watts, and after a 10 min break, they followed the testing exercise session, on the same treadmill: starting with a power of 30 watts, for four minutes, followed by a gradual increase of power and continuing until the appearance of the feeling of fatigue, perceived by each subject.

The chosen phytotherapeutic preparation contains Lepidium meyenii (Maca) root powder (500 mg) (1). Lepidium meyenii product (LMP) was given for 12 (LM1) and 21 (LM2) days, respectively, in a dose of 3 tablets per day, at 8.00-14.00-20.00, prior to physical stress.

2) The indicator determination program was the same for C, LM1, LM2, being carried out as follows:

- time 1 = T1 - before LM treatment
- time 2 = T2 - 15 min before exercise
- time 3 = T3 - 30 min after exercise
- time 4 = T4 - 4 h after exercise

3) Explorations

The examinations consisted of measuring:

- *anxiety (A)* - evaluated with Beck Anxiety Inventory (2): this scale is a self-report measure of anxiety, with 21 items. Scoring: 0 = not at all; 1 = mildly, but it didn't bother me much; 2 = moderately, it wasn't pleasant at times; 3 = severely, it bothered me a lot. The total score is the sum

of the 21 items: 0-21 = low anxiety; 22-35 = moderate anxiety; ≥ 36 = concerning anxiety.

- *glycemia (G)* - evaluated with a portable glucometer (mg/dl).

- *salivary pH (SpH)* - evaluated with the PHS-3G laboratory acidity meter, following a protocol according to an already developed model (Baliga et al., 2013): saliva was collected in the morning, after a 10-hour fast, during which subjects could only drink water; the subjects were asked to thoroughly rinse their mouth with bottled drinking water, and after 5 minutes to spit the entire saliva into the collector tube by flowing naturally to the front of the mouth, once a minute, for up to 10 minutes; during collection, the subjects were asked not to cough, talk, or lower their heads; the amount of collected saliva was 5 ml.

d) Statistical processing

The results obtained were analyzed using SPSS 19.0. statistical package.

For continuous data examination, Student's t test was used.

Results

We considered the parameter values for LM1 as a benchmark.

A. *Anxiety (A) analysis* (Table I)

For all groups, the dynamics of A was the same: the highest values were recorded immediately pre-stress (T2); the immediate post-stress values (T3) were close to immediate pre-stress values (T2); at 4 hours post-stress (T4), A values remained elevated compared to T1.

At T2, T3 and T4: the A values for C, compared to LM1 and LM2, were the highest; the values for LM2 were the lowest. C-LM1 differences were significant at T2 (p = 0.00001), T3 (p = 0.00001) and T4 (p = 0.00001). LM1-LM2 differences were significant at T2 (p = 0.00134), T3 (p = 0.000075) and T4 (p = 0.00197). T2-T3 differences were: not significant for C (p = 0.06545) and significant for LM 1 (p = 0.0002) and LM2 (p = 0.000034).

B. *Glycemia* (G) *analysis* (Table II)

For all groups, G dynamics was the same: pre-treatment (T1) values were close to immediate pre-stress values (T2); the highest values were registered - immediately post-stress (T3); at 4 hours post-stress (T4), G values remained elevated compared to T1 and close to those at T3.

At T3 and T4: G values for C - compared to LM1 and LM2 - were the highest; G values for LM2 were the lowest. C-LM1 differences were significant at T2 (p = 0.00001), T3 (p = 0.00001) and T4 (p = 0.00001). LM1-LM2 differences were significant at T3 (p = 0.00888) and T4 (p = 0.39798). T3-T4 differences were: not significant for C (p = 0.05978) and significant for LM1 (p = 0.0193) and LM2 (p = 0.0004).

C. *Salivary pH* (SpH) *analysis* (Table III)

For all groups, SpH dynamics was the same: pre-treatment values (T1) were close to immediate pre-stress values (T2); the highest values were recorded immediately post-stress (T3); at 4 hours post-stress (T4), SpH values remained elevated compared to T1 and close to those at T3.

Table I

Values for anxiety at moments T1-T4

Time		**T1**			**T2**			**T3**			**T4**	
Group	C	LM1	LM2	C	LM1	LM2	C	LM1	LM2	C	LM1	LM2
Mean	1.975	2.062	1.775	31.125	19.25	15.5	30.125	14.75	9.75	25.375	4.2375	3.1125
SD	0.2904	0.2175	0.3031	1.1659	1.7853	2.0615	1.1659	1.8540	1.7853	1.2183	0.5360	0.6772
Comparison with LM1 - p value	0.2669		0.0304	<.00001		0.0013	<.00001		0.00007	<.00001		0.0019
T2-T3 comparison - p value							0.06545	0.0002	0.00003			

Table II

Values for glycemia at moments T1-T4.

Time		**T1**			**T2**			**T3**			**T4**	
Group	C	LM1	LM2	C	LM1	LM2	C	LM1	LM2	C	LM1	LM2
Mean	71.25	71.625	70.875	71.25	72.625	73.5	148.75	131.25	123.875	146.125	123	114.5
SD	2.5860	7.4843	3.6550	2.1650	1.9960	2.7386	2.9047	6.3196	3.586	9.1093	7.1763	4.5552
Comparison with LM1 - p value	0.3979		0.3352	<.00001		0.0551	<.00001		0.00888	< 00001		0.0095
T3-T4 comparison - p value										0.0597	0.0193	0.0004

Table III

Values for salivary pH at moments T1-T4

Time		T1			T2			T3			T4	
Group	C	LM1	LM2	C	LM1	LM2	C	LM1	LM2	C	LM1	LM2
Mean	7.34	7.325	7.2375	7.3375	7.3625	7.2	8.4	8	7.6625	8.2125	7.6125	7.0625
SD	0.1798	0.1713	0.1866	0.1653	0.1408	0.1	0.1	0.1732	0.2446	0.3620	0.1832	0.2287
Comparison with LM1 - p value	0.448		0.1882	0.3826		0.3233	0.00006		0.0049	0.0007		0.0001
T3-T4 comparison - p value										0.1039	0.0006	0.0006

At T3 and T4: SpH values for C, compared to LM1 and LM2, were the highest; SpH values for LM2 were the lowest. C-LM1 differences were significant at T3 (p=0.00006) and T4 (p=0.00079). LM1-LM2 differences were significant at T3 (p=0.00498) and T4 (p=0.00016). T3-T4 differences were: not significant for C (p=0.1039) and significant for LM1 (p=0.00059) and LM2 (p=0.00066).

D. *Intergroup analysis, related to T2/T1, T2/T3, T2/T4*

a) *Anxiety* (Fig. 1). For all groups: the greatest differences between ratios were for T2/T1, and the smallest ones were for T2/T4. The T2/T1 ratio was the highest for C (15.7), and the lowest for LM2 (8.73). The T2/T4 and T2/T4 ratios were the lowest for C (1.03, and 1.23 respectively) and the highest for LM2 (1.59 and 4.9 respectively).

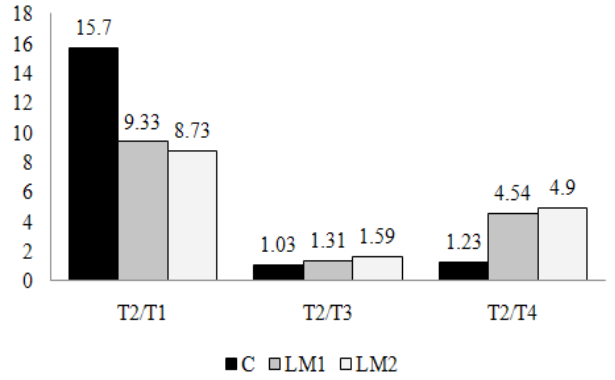

Fig. 1 – Intergroup analysis, related to anxiety, for: T2/T1, T2/T3, T2/T4.

b) *Glycemia* (Fig. 2). The greatest differences between the ratios were for T3/T1 (C=2.09, LM2=1.74) and T3/T2 (C=2.09, LM1=1.9), and the smallest ones were for T3/T4. The T3/T1 and T3/T2 ratios were highest for C (both 2.09) and the lowest for LM2 (1.74 and 1.69 respectively). The T3/T4 ratio was the lowest for C (1.02), and the highest for LM2 (1.09).

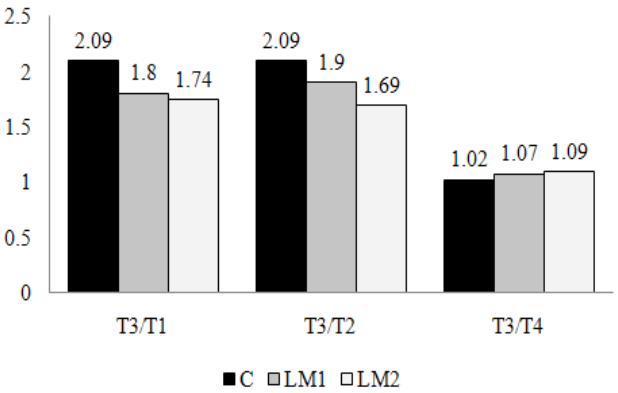

Fig. 2 – Intergroup analysis, related to glycemia, for: T3/T1, T3/T2, T3/T4.

c) *Salivary pH* (Fig. 3). The greatest differences between the ratios were for T3/T1, and the smallest ones were for T3/T4 (C=1.02; LM1=1.05). The T3/T1 and T3/T2 ratios were the highest for C (1.15 and 1.14 respectively) and the lowest for LM2 (1.07 for both). The T3/T4 ratio was the lowest for C (1.02), and the highest for LM2 (1.09).

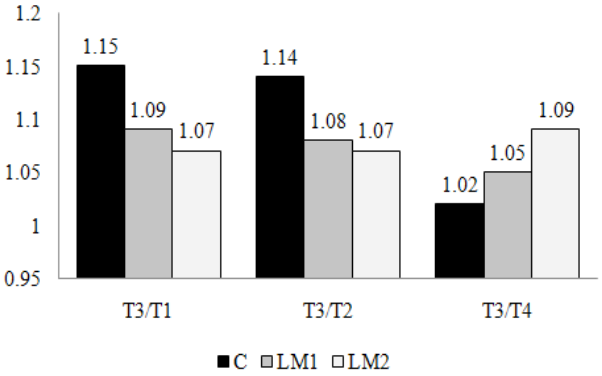

Fig. 3 – Intergroup analysis, related to salivary pH, for: T3/T1, T3/T2, T3/T4.

Discussion

1) *Analysis of the results of the present study*

The evolution of A, for all groups, had the highest increase in T2 values, which proves an anticipatory effect of stress, immediately prior to its production. The evolution of G and SpH, for all groups, had the highest increases in values at T3, which proves an important effect of stress immediately after its production.

The effect of physical stress on all parameters was the most intense for C. For A, the highest values being at T2 and T3, we compared the T2-T3 differences: it was found that the A values diminished immediately post-stress in LM2 (p=0.000034), compared to C (p=0.0002) and LM1 (p=0.06545). For G and SpH, the highest values being at T3 and T4, we compared the T3-T4 differences: G and SpH were found to be the lowest in LM2 at 4 hours post-stress (G, p=0.000034; SpH, p=0.00066), compared to C (G, p=0.0002; SpH, p=0.00059) and LM1 (G, p=0.06545; SpH, p=0.1039).

From the perspective of time ratios, it was found that the lowest effect of stress was on LM2. Parameter values increased the least, compared to T1: at T2, for A (T2/T1=8.73); at T3, for G (T3/T1=1.74) and SpH (T3/T1=1.07). Parameter values decreased the most, compared to T2: at T3, for A (T2/T3=1.59); at T4, for A (T2/T4=4.9), G (T3/T4=1.09) and SpH (T3/T4=31.09).

Therefore, PML provided a good anti-stress protection, the effect being much more important after 21 days (LM2) than after 12 days (LM1), the evidence being the significant LM1-LM2 differences at T2 (A, p=0.00134), at T3 (A, p=0.000075, G, p=0.00888, SpH, p=0.00498) and T4 (A, p=0.00197; G, p=0.00959; SpH, p=0.00016).

2) *Lepidium. Pubmed chronological evidence*

a) *Lepidium - History and framing*

Of the varied flora of the Andes (Flores et al., 2003) - also part of Lepidium meyenii (maca), - a cruciferous plant of different colors (Gonzales et al., 2009), of the genus Lepidium (Meissner et al., 2015), the only one in the world that grows natively at an altitude of 4,000-4,400 m (Tello et al., 1992).

b) *Lepidium - Stress*

Lepidium is known and used as an adaptogen (López-Fando et al., 2004) and as an antioxidant (Zha et al., 2014). Lepidium has a high content of polysaccharides (Zha et al., 2014). Animal studies have shown Lepidium efficiency by: protecting the alteration of spermatogenesis due to altitude stress (Gonzales et al., 2004); inhibition of lipid peroxidation (Gonzales-Castañeda et al., 2011); the antidepressant effect (Ai et al., 2014); protection against physical fatigue (Choi et al., 2012); reduction of oxidative stress, evidenced by decreased malondialdehyde (Yang et al., 2016); reduction of lactic acid under conditions of intense physical exertion (Tang et al., 2017).

c) *Lepidium - Sport*

Due to its valuable composition of polysaccharides, Lepidium is effective in sports: it improves the capacity of resistance to swimming (Choi et al., 2012); reduces post-exercise fatigue (Yang et al., 2016; Li et al., 2018); increases the duration of physical effort in swimming and its speed of achievement (Tang et al., 2017); extends the exhaustive swimming time (Zheng et al., 2019).

d) *Lepidium - Anxiety*

Lepidium has been shown to be effective in modulating stress: it reduces corticosterone (López-Fando et al., 2004); reduces anxiety and depression (Brooks et al., 2008); modulates diastolic blood pressure (Stojanovska et al., 2015); and increases libido (Gonzales et al., 2009).

e) *Lepidium - Glycemia*

Lepidium has beneficial effects in modulating blood sugar: it reduces blood sugar in diabetic rats (Eddouks et al., 2005; Gonzales et al., 2013); increases glucose tolerance (Vecera et al., 2007); normalizes blood glucose and glycosuria (Eddouks & Maghrani, 2008); reduces glycemia after exposure to low and high altitude (Gonzales-Arimborgo et al., 2016); after exposure to methanol, it normalizes blood sugar, improves lipid levels and reduces oxidative stress (Attia et al., 2019).

The results obtained in our study on anxiety and glycemia, by using a *Lepidium meyenii* product, are consistent with data from recent studies related to the changes of these parameters, under the action of stress, sport and *Lepidium* species. This study also confirms the modulating effect of *Lepidium meyenii* on anxiety and glycemia. The difference from the quoted studies is that our study has shown the effectiveness of *Lepidium meyenii* administration not only on anxiety and glycemia, but also on salivary pH, in physical stress caused by walking very fast on the treadmill, in sedentary subjects.

Conclusions

1. Dynamic developments of A, G, SpH were different for C, LM1/ LM2.
2. LM significantly reduced A/G, increased SpH, with a more important influence on A.
3. LM2 effect was more intense compared to LM1.
4. We suggest that LM may be useful in A, G, SpH modulation, in stress caused by walking very fast on the treadmill, in sedentary people, but further research is needed.

Conflicts of interest

Nothing to declare.

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