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Research paper

The effect of long term physical exercises on plasma cortisol levels

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Abstract

Regular physical exercises have shown to improve health. Stress can cause great impact on individual's mental health as well as physical health. Plasma cortisol is used as a biomarker to measure stress. This study was carried out to evaluate the effect of long-term physical exercises on cortisol levels in healthy young men. The study was carried out on four study groups; non–exercised control group (NE), exercised for 6 months (E6M), exercised for 18 months (E18M) and exercised for 30 months (E30M). Thirty participants who underwent regular physical exercises for different time periods were included in each exercised group. Thirty controls were also recruited. Plasma cortisol was measured using ELIZA method and compared to the patterns of plasma glucose levels. Plasma cortisol levels of all exercised groups were significantly less than that of control group ($p<0.05$). A significant reduction of plasma cortisol level was observed in E6M ($p<0.001$) and E18 M ($p<0.001$). Plasma cortisol level of E30M was higher than E6M and E18M but less than the control group. Plasma glucose levels followed the same pattern as cortisol. The results of this study suggest that prolong exercises favorably alters the cortisol and glucose levels indicating reduced stress levels in young adults. The study clearly indicates that the prolong exercises have positive effect on the stress marker; plasma cortisol level as well as overall health of an individual.

Keywords: *Long Term Exercises; Cortisol; Stress; Glucose; Health.*

1. Introduction

Stress is generally described as a feeling of emotionally overwhelmed, anxious or neglected (Baum, 1990). It is also associated with biochemical, physiological and behavioral changes (Baum, 1990). Stress can cause both psychological health problems as well as physical health. Too much stress causes unhappiness, depression, and anxiety and has become a critical factor in morbidity and mortality (Berger et al. 1988, Lynch, 1975). Many other illnesses such as coronary heart disease, stroke and cancer are associated with stress (Berger et al. 1988, Jenkins, 1976, Maier & Laudenslager, 1985).

It has been well documented that regular physical exercises improve health (Cornelissen & Fagard, 2005, Davis et al. 2008, Choudhary & Binawara 2012, Bandara et al. 2016). In addition to the physiological benefits, a number of psychological benefits are also associated with physical exercises such as reduced depression, anxiety, anger as well as improved mood (Byrne & Byrne, 1993, Salmon, 2001; Benton, & Thirlaway, 1992). Physical activities have helped individuals to control stress levels (Hassmen et al. 2000, Nguyen-Michel et al. 2006). The immediate effects of exercise on stress have also been documented (deVries, 1968). The benefits of long-term physical exercises have been reported in diseased populations and in animal models (Blumenthal et al. 2005, Lalanza et al. 2015). However, the conclusions of most of these studies were mainly based on a questionnaire based surveys rather than measuring biochemical markers of stress.

Cortisol is the main glucocorticoid hormone in humans, and it is the prime hormone responsible for the stress response (Lee et al. 2015). Plasma cortisol has been used as a biomarker to measure stress (Kuoppasalmi et al. 1980). The immediate effect of exercise on plasma cortisol levels has also been evaluated (Kuoppasalmi et al, 1980). Nevertheless, the effect of long-term physical exercise on stress measured by cortisol has been overlooked. It has been found that long-term physical exercises help to maintain or increase brain norepinephrine levels (Brown & Van Huss, 1973, Brown et al. 1979, Dishman et al. 1997). Cortisol is also known to affect plasma glucose levels (Khani & John, 2001). Hence the aim of this study was to understand the effect of intense long term physical exercises on plasma cortisol levels and to determine if the observed variations correlate to the plasma glucose levels.

2. Materials and methods

The participants for this study were comprised of 120 healthy students recruited to the General Sir John Kotelawala Defence University (KDU), Ratmalana, Sri Lanka. The young officer cadets recruited to the KDU undergoes regular intense physical training in addition to their academic work. Ninety cadets were grouped according to the duration of the exercise period they underwent; six months (E6M), eighteen months (E18M), thirty months (E30M). As the control group, civilian students recruited to the KDU who do not participate in any form of regular exercises were taken [non-exercised (NE)]. All of them were randomly selected and consisted of age (18 -22 years), and gender matched four groups with 30 participants in each group. The ethical approval for this study was obtained from the Ethics Review Committee of the KDU, and the study was conducted according to the

Declaration of Helsinki. Written informed consent was obtained from all participants.

2.1. Exercise protocol

The exercise protocol conducted in this study was a supervised, progressive, strength training program, with 45 minute to 2 hour sessions for five days a week which included running, stretching and muscle strengthening exercises. Exercised groups also had to participate for a 45 minute swim per week in addition to the above mentioned exercises.

2.2. Blood sampling and biochemical determination

All participants had to undergo 12 hours of overnight fast prior to the experimental analysis. Following morning 5 mL of venous blood samples were drawn into heparinized tubes. The samples were centrifuged immediately at 1500×g for 15 min to separate plasma. Plasma samples were used to measure cortisol and glucose. Plasma cortisol levels were measured using an ELISA kit (Human, Germany). Glucose concentration was measured by GLUCOSE GOD/PAP (Biolab, France). All the reactions were carried out according to the manufacturer's protocols and colorimetric determination was done at given wave lengths using a spectrophotometer. An interviewer administrated questionnaire was given to the participants to collect information about the participants' sleeping behavior, alcohol usage, smoking habits and medication usage.

2.3. Statistical analysis

Statistical analyses were performed using SPSS 20.0 statistical software. Analysis of variance (ANOVA) and a post-hoc test was used to evaluate the mean differences between of exercise groups and NE group. P-value of 0.05 was considered as the cut off for significance.

3. Results

Mean plasma cortisol concentrations of different study groups are shown in table 1 and fig.1. Cortisol concentration of the NE group is significantly different from that of the exercised groups and lies near the upper limit of a normal cortisol range of a healthy adult. Both E6M and E18M groups showed significantly lower cortisol values compared to the control group. However E30M group had a higher plasma cortisol level compared to the E6M and E18M groups but was not higher than the control group. Plasma glucose concentrations of each group were correlated with the respective cortisol levels. Both E6M and E18M groups had a lower a plasma glucose levels than the controls group. But in consistent with the trend seen in plasma cortisol levels, the plasma glucose level of E30M group was also higher than E6M and E18M groups and was lower than the control group.

4. Discussion

This research was conducted to investigate the effect of long term exercises on stress. The study reveals that the regular physical exercises conducted for long period (>6 months) significantly reduce the plasma cortisol levels which showed a positive correlation with the plasma glucose levels. Blood samples were collected from 30 subjects from each group; however, we had to exclude one subject from each E6M and E30M groups as their blood was clotted at the time of experiment being conducted. Analysis of the questionnaire revealed that none of the subjects of this study had smoked or consumed alcohol or any alcohol containing beverages during 48 hours prior to the time of the collection of blood. In addition, all study subjects have had at least 5 hours sleep in the previous night. No study subject was on any kind of medication or vitamin supplement.

Several attempts have been made to understand the effects of physical exercises on various metabolic parameters. A study conducted by Keselman et al showed that relatively short running-races can increase insulin and cortisol levels while inducing a reduction in insulin sensitivity (Dmitrašinović et al. 2016). However, Verbickas et al in 2017 showed that the cortisol levels in blood decreased at 24h after energy demanding sprint interval exercise and mechanically demanding stretch-shortening cycle exercise (Keselman et al. 2017). Dmitrašinović et al in 2016 found that magnesium supplementation reduces cortisol and IL6 levels in blood levels following strenuous physical exercise (Slimani et al. 2017). In addition, the effect of competition among players during sports activities on stress levels has also been evaluated (Verbickas et al. 2017). Further, this study also discusses how athletes cope up with the stress induced by competition.

The effect of physical exercises on several stress conditions has also been evaluated. An exercise program conducted for two to three times a week results in significantly less depression, anger, cynical distrust, and stress (Hassmen et al. 2000). In addition, these exercises have improved the health and fitness of the individuals who participated in this program (Hassmen et al. 2000). Interestingly it has been shown that students who experienced stress have fewer health issues while they were participating in physical activities (Haugland et al. 2003, Thome & Espelage, 2004). Nonetheless, the effect of intense long term exercises on stress has not been well studied. Long term exercises slightly improved cognitive function in adults based on Wechsler Memory Scale (WMS) (Hill et al. 1993). Most studies are based on questionnaires and the changes in biochemical parameters of stress responses after exposure to long term exercises have not been evaluated. Hence the present study may provide information to the existing knowledge on the effect of intense long term exercises on psychological status.

Cortisol is a glucocorticoid hormone, secreted by the adrenal cortex in response to physiological or psychological stressors (Hackney, 2006, Wittert et al. 1996). Upon released into the blood, cortisol acts on a variety of peripheral tissues, such as skeletal muscle, adipose tissue, and the liver. In the adipose tissues, it induces the hydrolysis of triglycerides into free fatty acids and glycerol (Hackney, 2006, McMurray & Hackney, 2000, Viru & Viru, 2004). It has been found that cortisol increases glycogen breakdown in the liver (Kalamidas & Kotoulas, 2000). Further, cortisol has shown to stimulate gluconeogenesis in the liver, which provides additional glucose to generate energy (Viru & Viru, 2004). However, the long-term effects of cortisol on glucose metabolism are yet to be understood.

In our study, we observed lower plasma cortisol and glucose levels in all three exercised groups compared to the non-exercised group. This clearly indicates that regular physical exercises have direct effect on reducing physiological stress levels in young men in an academically stressful environment while improving health. The key causative factors of academic stress have been identified as fear of failing examinations, time management problems, concerns on academic abilities such as grades, etc. (Pozos-Radilloa et al. 2014). The American College Health Association in 2014 stated stress as a key factor that can interfere with academic conductance. Accordingly, academic stress can cause anxiety, depression as well as physical illness in students (Lal, 2014, Deb et al. 2015). We believe that this is a complete scientific evaluation of the effect of intensive long term exercises on plasma cortisol levels. Its correlation with the plasma glucose levels was also evaluated. Results of this study reveal that the long term regular exercises reduce plasma cortisol levels in students in an academically stressful environment with a positive correlation between plasma cortisol and glucose levels.

Table 1: Means of Plasma Cortisol and Glucose Concentrations Seen in Different Study Groups and P Values of One Way ANOVA.

Biochemical parameter	NE	E6M	E18M	E30M	P One way ANOVA
Cortisol (ng/ml)	188.52±12.44	138.09 ±3.84**	118.66± 4.87**	165.98 ±6.88	0.000
Glucose ǂ (mg/dl)	90.2±1.7	80.7±1.7	75±1.8*	85±3.5	0.04

ǂ the data taken from Bandara et al, 2016.
* P <0.05 for the comparison with the control group.
** P <0.001 for the comparison with the control group.

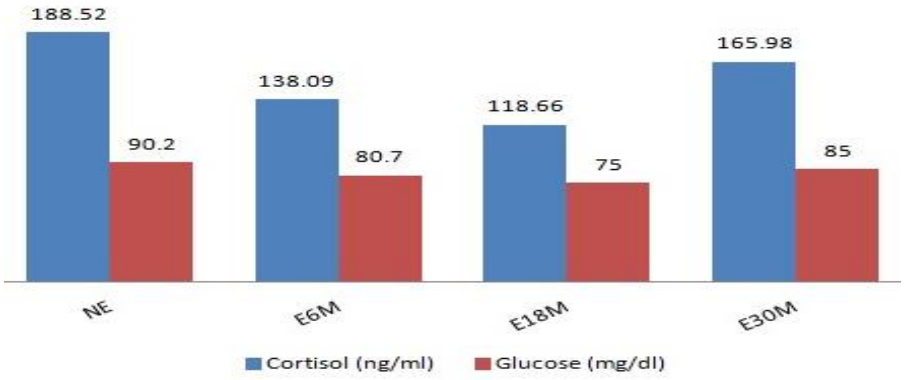

Fig. 1: Plasma Cortisol and Glucose Levels in Different Groups (Non–exercised control group (NE), exercised for 6 months (E6M), exercised for 18 months (E18M) and exercised for 30 months (E30M)).

5. Conclusions

Long term intense physical exercises favorably alter the biochemical indicators of mental and physical health.

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Conflict of interest

Authors declare there is no conflict of interest.

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