ENDOCRINE RESEARCH, 22(4), 763-767 (1996)

EXERCISE AT LOW ALTITUDE (JORDAN VALLEY) CAUSES CHANGES IN SERUM LEVELS OF ACTH, INSULIN, CORTISOL AND LACTATE

El-Migdadi F*, Bashir N+*, Hasan Z*, Al-Hader A-A*, and Gharaibeh M*

+ Department of Biological Sciences, Al-Bayt University, Mafraq-JORDAN
* Department of Physiology and Biochemistry, School of Medicine, University of Science and Technology, Irbid-JORDAN

ABSTRACT

This study was designed to examine the effects of exercise on adrenocorticotropic hormone (ACTH) and cortisol at low altitude (350 meters below sea level) and to compare these effects with those at a moderate level altitude (620 meters above sea level). Ten male trained athletes participated in a 21-Km non-competitive race. Serum levels of ACTH, luteinizing hormone (LH), growth hormone and cortisol were measured before and after the race at each of the altitudes. A significant increase in serum levels of ACTH was observed in response to this exercise only at low altitude. Serum levels of growth hormone were increased at both altitudes. Those of LH were not affected. Serum cortisol levels were increased following exercise at both altitudes. It is proposed here that ACTH may play a role in acclimatization to exercise at low altitudes. The role of growth hormone and LH in this conditioning process seems to be insignificant. Additionally, serum levels of insulin and lactate were also measured in these experiments. Exercise caused a decrease in serum insulin levels at both altitudes. Serum levels of lactate were decreased only at low altitude. These changes of serum levels of insulin and lactate suggest a type of metabolic adjustment to meet energy requirements. Changes in energy metabolism can be correlated by changes in the ratio of insulin to serum cortisol levels and those of other counter-regulatory hormones in response to exercise at both altitudes.

INTRODUCTION

Exercise is well known to cause increases in the serum levels of the anterior pituitary and adrenocortical hormones (1). Strenuous exercise was found to increase plasma levels of ACTH (2) and cortisol with no change in those of LH (3). Growth hormone levels were increased in response to exercise (4). Jordan is a suitable place to perform experiments that involve different environmental conditions in terms of temperature, humidity, oxygen content of the air and altitude. Irbid, 620 meters above sea level, and the Jordan valley, 350 meters below sea level, the lowest point on land on our planet were the sites of these experiments. Serum levels of ACTH, LH, growth hormone and cortisol were examined following a 21-Km non-competitive run at both altitudes. Serum levels of insulin and lactate were also investigated following exercise. This design provides a model to study physiological responses to changes in the environment in terms of altitude.

MATERIALS and METHODS

Ten male athletes, aged 19-30 year old, participated in this study. A 21-Km non-competitive race took place at both altitudes, Irbid and Jordan Valley. Serum ACTH, LH, growth hormone, cortisol and insulin were determined by radio immunoassay using the available commercial Kits from DPC (Los Angeles, California, USA). Lactate levels were determined by Biosensor Analyzer Microzym-L (S.G.I., Toulouse, France). Data were expressed as per cent of mean $\pm$ standard deviation (SD) of post-exercise values as compared to that of pre-exercise values. Differences between mean values of pre-exercise and post-exercise data in each experiment were tested by Student t-test. A p value of <0.05 was considered to be significant.

RESULTS and DISCUSSION

Previous studies have shown no change in serum levels of ACTH in response to exercise (4). Our data concerning ACTH response to exercise at above sea level support these reports. However, ACTH secretion in trained people seems to increase following exercise at low altitude (Table I). The hyperoxic and hyper barometric pressures of low altitudes as compared to those of

TABLE I. The Effect of Exercise on Serum Levels of ACTH, Growth Hormone, LH, Cortisol, Insulin and Lactate in athletes.

Serum Levels	620 Meters Above Sea Level	350 Meters Below Sea Level
ACTH	110%	140%*
Growth Hormone	350%*	503%*
Leuteinizing Hormone	61%	82%
Cortisol	141%*	153%*
Insulin	73%*	79%*
Insulin/ACTH, Growth Hormone and Cortisol Ratio	↓	↓↓
Lactate	125%	156%*

* p value < 0.05 when compared to the corresponding level before the race.

moderate altitudes may be responsible for the altered pattern in ACTH secretion in response to exercise at low altitude. LH secretion, on the other hand, does not seem to be affected by exercise at both altitudes supporting what was previously known at above sea level (3). Secretion of growth hormone is significantly increased by exercise. In addition, growth hormone response is altitude-independent.

The increase in serum cortisol levels in response to exercise at moderate altitude is in agreement with what was reported at above sea level (5). Changes in serum cortisol levels may be attributed to the stimulatory action of exercise on ACTH and the pituitary-adrenal axis (6). However, the role of ACTH in this increase at low altitude seems to be minimal.

The hyperoxia and high barometric pressure of low altitude are suggested here to be responsible for the changes in hormonal homeostasis in response to exercise. It is believed that a shift in fuel metabolism to keep up ATP homeostasis in the working muscle is required under conditions of exercise at low altitude. The increase in ACTH secretion and growth hormone was associated with an increase in cortisol level. All these hormones are considered counter-regulatory to insulin hormones. As can be seen on Table I, serum levels of insulin decreased in response to exercise. Serum lactate levels, on the other hand, increased in response to exercise; and this increase was observed exclusively at low altitude. Additionally, serum pre-exercise levels of lactate at low altitude were lower than those at above sea level. Low glucose levels at low altitude (7) may be responsible for a decrease in glucose-6-phosphate, and thus a decreased flux through fructose-6-phosphate/fructose-1, 6-bisphosphate, which is controlled by the activity of phosphofructokinase-1 (PFK-1). Additionally, our efforts had shown that transfer from above sea level to low altitude causes a significant decrease in PFK-1 activity and a significant increase in serum ATP (8). An increase in glycogenolysis, a result of increased epinephrine secretion during exercise (9), can also lead to an increase in muscle glycolysis (anaerobic) and a subsequent increase in the serum level of lactate in response to exercise.

ACKNOWLEDGMENTS

The authers wish to acknowledge Professor Alexander Charles Brownie of Dundee University for his critical reading of the manuscript. This work was supported by Research Foundation of Jordan University of Science and Technology.

REFERENCES

1. Costill DL. 1972 Physiology of Marathon Running. J Am Med Assoc 221: 1024-1029.

2. Carr DB, Bullen BA, Skirnar GS, Arnold MA, Rosenblat M, Beitins IZ, Martin JB, Mcarthur JW. 1981 N Engl J Med 305: 560-563.

3. Dessypris A, Kuoppasalmi K, Adlercreutz H. 1976 J Steroid Biochem 7: 33-37.

4. Buono MJ, Yeager JE, Suces AA. 1987 J Appl Physiol 63(6): 2499-2500.

5. Newmark RS, Himathongkam T, Martin RP, Cooper KH, Rose LJ. 1976 J Clin Endocrinol 42: 393-395.

6. Cashmore CG, Davies CTM, Few JD. 1977 J Endocrinol 72: 19-22.

7. Khraisha S. 1990 J Aviat Space Environm Med 61: 145-147.

8. Bashir N. 1995 J Aviat Space Environm Med In Press.

9. Jansson E, Hjemdahl P, Kaijser L. 1986 J Appl Physiol 66: 1466-1470.