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Full Length Research Paper

Biochemical factors relevant to kidney functions among Jordanian top athletes

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The aim of this research was to examine the biochemical factors related to kidney functions such as glucose, urea, creatinine, sodium and potassium levels among Jordanian top level athletes. Eighty athletes (67 males and 13 females) participated were chosen to take part in this study. The means height, weight, age, gender and Body Mass Index (BMI) were matched by a control group consist of 81 normal adolescents. Data were analyzed using SPSS package two-sample t-test, ANOVA and Scheffe post hoc test for the significant physiological variables The results showed that the levels of serum urea, creatinine and potassium in Jordanian top athletes were statistically significantly higher than the control group ($p<0.05$). Our finding indicates that a significant difference in correlation between BMI and creatinine were observed in the experimental group. We concluded that the most abnormalities observed on routine biochemical screening in top Jordanian athletes are of no clinical significance.

Key words: athletes, urea, creatinine, hyperkalaemia, hypokalaemia, hypornatraemia, hypernatraemia.

INTRODUCTION

Physical exercise is a bodily activity that develops and maintains physical fitness and overall health. It is often practiced to strengthen muscles and the cardiovascular system, and to hone athletic skills. Frequent and regular physical exercise boosts the immune system, and helps prevent diseases of affluence such as heart disease, cardiovascular disease, Type 2 diabetes and obesity. It also improves mental health and helps prevent depression (Stampfer, et al., 2006; Manson, et al., 2005). Exercises are generally grouped into three types depending on the overall effect they have on the human body: Flexibility exercises such as stretching improve the range of motion of muscles and joints (O'Connor, et al., 2006). Aerobic exercises such as cycling, walking, running, hiking, and playing tennis focus on increasing cardiovascular endurance (Wilmore, et al., 2006). Anaerobic exercises such as weight training, functional training or sprinting increase short-term muscle strength. (De Voss et al., 2005). Competitive sport imposes substantial energy, mechanical, mental and emotional burdens on the human. This reflects, among other things, on a number of biochemical and hematological properties, which display significant differences between athletes and non-athletes in blood samples collected at rest. (Nikolaidis et al., 2003; Mayr et al., 2006). The kidneys constitute less than 0.5% of the body mass, yet they receive almost one fourth (22%) of the cardiac output at rest (Johnson and Byrne, 1998; Garrett and Kirkendall, 2000). During exercise, renal blood flow to the kidney is greatly reduced, as the muscles demand for oxygen and blood flow is increased (Mueller et al., 1998; Garrett and Kirkendall, 2000). Since the kidneys do not consume large amounts of oxygen, demand only a small portion of the cardiac output, and do not contribute to performance during exercise, there has been very little investigation into the physiology of the kidney during and after exercise. There have been a few studies that looked at renal function and glomerular filtration rate (GFR) in the acute stage (1- 72 hours) following exercise (Poortmans et al., 1995; Irving et al., 1990). Lippi et al., (2008) evaluated GFR, estimated by the recommended Modification of Diet in Renal Disease (MDRD) equation in athletes and concluded that the average intensity of daily

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Table (1). Means and standard deviations for age, weight, height and BMI for each group (experimental and control)

Variable	Group	N	Mean	Std. Deviation
Age	exp	80	18.68	2.04
	cont	81	19.43	1.14
Weight	exp	80	71.99	13.79
	cont	81	65.10	11.40
Height	exp	80	1.79	0.11
	cont	81	1.71	0.10
BMI	exp	80	22.42	2.65
	cont	81	22.15	3.38

physical exercise, but not the body mass index, was inversely associated with serum creatinine and positively associated with the estimated GFR and the MDRD equation should be used with caution in athletes, and it should consider intensity and type of physical exercise. Renal or kidney function tests look at the way the kidneys are working to clean the blood. Kidneys clean the blood of waste products of the metabolic system which would otherwise poison the body. The test looks at whether the kidneys are failing by measuring the waste products left behind in the blood. There are several blood tests that can aid in evaluating kidney functions. These include urea as product of protein metabolism, creatinine a by-product of muscle energy metabolism and measurement of the blood levels of other elements regulated in part by the kidneys These include glucose, electrolytes as sodium, potassium, chloride .

There is a correlation between creatinine concentration and BMI in elite athletes competing in different sports characterized by different kinds of training, competitive season, and involvement of aerobic and anaerobic metabolism **(**Banfi**,** et al., 2006**).** Athletes are usually thought to be physically normal and healthy by definition, but the high training workload and psychophysical stress from competitions may modify their homoeostasis, inducing apparently pathological biochemical and hematological values. This study aims to examine the biochemical factors relevant to kidney functions among the Jordanian top level athletes such as Urea, Creatinine, Na and K. The abnormality of these factors is known to have dangerous impact on the health of the athletes.

MATERIAL AND METHODS

EXPERIMENTAL SUBJECTS

Eighty Jordanian top level athletes (67 males and 13 females, mean age 18.6 ± 1 year) with training experience of at least 5 years and with a minimal training load of eighteen training hours per week participating in competitive different sports (aerobic and anaerobic) were included in this study. A group of healthy male and female adolescents (control group), matched for age and gender was also included (n=81). No subject revealed evidences of cardiovascular disease, diabetes (fasting glucose <7 mmol/liter) or hypertension (blood pressure <130/80 mm Hg) when tested by specialized physicians.

Athletes included in this study represented different sport metabolisms; aerobic anaerobic and anaerobic-aerobic. Aerobic group (n=22) included long distance, swimming and long distance running athletes. The anaerobic group (n=26) included, basketball, taekwandoo, volleyball and short distance running. The anaerobic-aerobic (n=32) included players football. All subjects submitted their written consents to a single blood sampling. None of the athletes participated in this study was using any type of special diets in the last two months prior to the study as they were out of the competitive phase and as they responded in the special ques-tioneer prepared for this goal. The study was approved by the Institutional Review Board of the Faculty of Physical Education, University of Jordan, and Amman-Jordan.

BLOOD COLLECTION

Blood samples were collected in plain tubes from the athletes and control group from the antecubital vein between 8 to 10 a.m., in a sitting position after 12 h of fasting for biochemical investigations. Blood samples were then allowed to clot, and then serum was obtained by centrifuging at 4000rpm (Cenformix).

METHODS

Serum glucose and urea were examined 12 h of fasting and 18 h after last training by automated analyser using commercial analytical kits from Sigma (St. Louis, Mo, USA). The enzymatic method for creatinine in serum has the speed and precision necessary for routine clinical laboratory use, the method appears to be specific for creatinine. Sodium and potassium were measured by using the ion selective electrod (ISE).

STATISTICAL ANALYSES

Data were treated using SPSS. Means, standard deviations, t-test, one way ANOVA for the physiological variables according to group and Scheffe post hoc test for the significant physiological variables. A significance level of 0.05 was used through out the whole study.

RESULTS

The anthropometrical characteristics as age, weight, height and BMI of athletes from different sport disciplines are shown in Table 1. The results revealed homogeneity between the different variables in the two groups. Significant differences (P <0.05) appeared between the experimental and control groups over urea, creatinine, and K but not glucose and sodium (Table 2). Means and standard deviations for the measured physiological variables in each group are presented in Table 3. The results of one way ANOVA for the physiological variables according to group are shown in Table 4. Significant differences appeared between the experimental and control group over the physiological variables except for glucose. According to Sheffe post hoc test (Table 5), differences were significant between the aerobic group and the control group over all the variables except for Na. Regarding the anaerobic group and the control group slight

Table (2). Results of t test for the study variables between the tow groups (experimental and control).

Variable	Group	N	Mean	Std. Deviation	T value	pro
Gloucose mmol/l	exp	80	4.54	0.88	0.54	0.586
	cont	81	4.60	0.42		
Urea mmol/l	exp	80	4.66	1.12	6.97	0.000*
	cont	81	3.65	0.66		
Creatinine mmol/l	exp	80	79.84	14.24	9.38	0.000*
	cont	81	60.51	11.78		
Na mmol/l	exp	80	137.32	27.66	0.67	0.503
	cont	81	135.26	1.39		
K Mmol/l	exp	80	4.64	0.57	6.67	0.000*
	cont	81	4.18	0.24		

Table (3). Means and standard deviations for the physiological variables

Variable	Group	n	Mean	sd
Gloucose mmol/l	aerobic	22	4.41	0.73
	anaerobic	26	4.81	1.08
	aerobic- anaerobic	32	4.41	0.77
	cont	81	4.60	0.42
Urea mmol/l	Aerobic	22	5.18	1.36
	Anaerobic	26	4.41	0.88
	aerobic- anaerobic	32	4.51	1.03
	cont	81	3.65	0.66
Creatinine mmol/l	aerobic	22	79.50	16.60
	anaerobic	26	86.15	10.60
	aerobic- anaerobic	32	74.94	13.46
	cont	81	60.51	11.78
Na mmol/l	aerobic	22	141.66	4.64
	anaerobic	26	126.55	46.71
	aerobic- anaerobic	32	143.10	5.50
	cont	81	135.26	1.39
K mmol/l	aerobic	22	4.68	0.42
	anaerobic	26	4.86	0.70
	aerobic- anaerobic	32	4.42	0.45
	cont	81	4.18	0.24

differences ($p<0.05$) also existed over all the variables except for Na. Urea and creatinine were significantly differ between the control group from one hand and the aerobic- anaerobic on the other hand. Moreover there was an also significant difference between the amount of urea between the aerobic and anaerobic (5.18±1.36 and 4.41±0.88 mmol/l respectively). Significant differences ($p<0.05$) appeared over creatinine, Na^+, and K^+ between aerobic and anaerobic groups while no significant differences was observed between the aerobic and the (aerobic - anaerobic) groups for these variables . The highest value for urea was noted in aerobic group (5.18 ± 1.36 mmol/l). The anaerobic group showed the highest level of creatinine and K^+ (86.15±10.60 μmol/L, 4.86 ± 0.70 mmol/L or mEq/L respectively). The aerobic- anaerobic group showed the highest level of Na^+ (143.10±5.50).

Table 6 showed the correlation between BMI and creatinine in experimental and control groups. Significant differences in correlation were observed in the experimental group.

DISCUSSION

The clinical utility of biochemical screening using multiple parameters has often been assessed in the general non-athletic population. Athletes are usually thought to be physically normal and healthy by definition, but the high training workload and psychophysical stress from competitions may modify their homoeostasis, inducing apparently pathological biochemical and hematological values. Sports medicine's continued growth and development may help the benefits of physical activity to be fully and safely realized. Serum levels of urea and creatinine as waste products formed during the digestion of proteins and in urine as the vehicle for ridding the body of nitrogen is used as indicators for renal function. Athletes on a high protein diet may have higher-than-normal levels of urea in the bloodstream. Our results revealed a significant increase in serum urea level in experimental group compared to control group, (4.66±1.12 and 3.65 ± 0.66 mmol/l respectively) even it is within normal range (1.2- 7.0 mmol/l). Increases in this parameter after exercise is very well described (Clarkson et al., 2006; Nagel et al., 2006). It is thought to reflect increases in production secondary to degradation of amino acids after muscle cell damage. Our results revealed that the type of sport also play a role in serum urea concentration. Aerobic athletes showed significant higher urea concentration than the anaerobic group while, none significant increase in the level for aerobic group was observed when compared to aerobic-anaerobic group. An increase in urea concentration may be related to a reduction in renal blood flow (and glome-

Table 4. One way ANOVA for the physiological variables according to group.

Variable	Variation source	Sum of Squares	df	Mean Square	F	Sig.
Gloucose mmol/l	Between Groups	2.96	3	0.99	2.15	0.096
	Within Groups	72.09	157	0.46		
	Total	75.05	160			
Urea mmol/l	Between Groups	49.30	3	16.43	20.47	0.000*
	Within Groups	126.06	157	0.80		
	Total	175.36	160			
Creatinine mmol/l	Between Groups	16848.98	3	5616.33	34.82	0.000*
	Within Groups	25323.01	157	161.29		
	Total	42171.99	160			
Na mmol/l	Between Groups	4671.82	3	1557.27	4.36	0.006*
	Within Groups	56079.94	157	357.20		
	Total	60751.76	160			
K mmol/l	Between Groups	11.20	3	3.73	21.72	0.000*
	Within Groups	26.98	157	0.17		
	Total	38.18	160			

Table 5. Scheffe post hoc test for the significant physiological variables.

variable	mean	Subgroup	anaerobic	both	cont
Urea mmol/l	5.18	aerobic	0.77*	0.67	1.53*
	4.41	anaerobic		-0.10	0.76*
	4.51	both			0.86*
	3.65	cont			
Creatinine mmol/l	79.50	aerobic	-6.65	4.56	18.99*
	86.15	anaerobic		11.21*	25.64*
	74.94	both			14.43*
	60.51	cont			
Na mmol/l	141.66	aerobic	15.11	-1.44	6.40
	126.55	anaerobic		-16.55*	-8.71
	143.10	both			7.84
	135.26	cont			
K mmol/l	4.68	aerobic	-0.18	0.26	0.50*
	4.86	anaerobic		0.44*	0.68*
	4.42	both			0.24
	4.18	cont			

merular filtration rate) secondary to fluid volume deficiency, increased protein catabolism, and/or bleeding into the intestine, all of which may occur as a result of overload training (Gastmann, et al., 1998; Noakes et al., 1998).

The concentration of creatinine in serum is the most widely used and commonly accepted measure of renal function in clinical medicine (Perrone 1992). Our results showed significant increase in creatinine concentration in the experimental group compared to the control group, (79.8 and 60.5 µmol/L respectively). The typical human reference ranges are 0.6 to 1.1 mg/dL (about 45-90 µmol/L) for women and 0.7 to 1.3 mg/dL (60-110 µmol/L) for men. However, serum creatinine as an indirect marker of glomerular filtration rate is affected by age, sex, race, diet and mainly body mass index (Rigalleau et al., 2003). Athletes in size related sports such as football have been shown to routinely be in the 75th percentile or above in both height and weight charts within their respective age groups (Malina et al., 2005). This is one major sport in which the physicality and strength of an athlete can outweigh one's talent and skill which can lead to an over-

Table 6. Correlation between BMI and creatinine in each sub group.

Group	N	BMI	Creatinine	r	p- value
experimental	80	22.42±2.65	79.84±14.24	0.356	0.001*
Control	81	22.15±3.38	60.51±11.78	0.211	0.059

emphasis on un-natural size and weight gains (Bale et al., 1994). The correlation between creatinine concentration and BMI in elite athletes competing in different sports characterized by different kinds of training, competitive season, and involvement of aerobic and anaerobic metabolism (Banfi**,** et al., 2006). The results of the study by Russell and Jeremy, (2007) show that a signifycant increase in BMI in football players transitioning from high school to college athletics. The increase in risk factors for cardiovascular disease and diabetes also exists as the athletes BMI increases. This suggests that without a change in habit or an intervention, the athlete is at an increased risk to develop health problems as a result of the pressures. Our results indicate the significant differences in correlation between BMI and experimental group and a weak, non significant positive correlation between BMI, anaerobic and anaerobic-aerobic metabolism .

Electrolyte levels are tightly controlled by several hormones and by the kidneys, which are primarily responsible for retaining and removing electrolytes when necessary and keeping them in a constant state of balance. An electrolyte imbalance can lead to serious health issues, including eventual death if not corrected. The most common imbalances occur with sodium and potassium. Such physiological variables related to glomerular filtration of the kidney as Na^+ and K^+ as the major cations of the extracellular and intracellular fluid were also studied. Our findings showed that there no significant differences in the serum Na^+ in experimental group (137.32 ± 27.66 mmol/l or mEq/L) compared to control (135.26 ± 1.39 mmol/l or mEq/L), even it is within normal rang for athletes and nonathletes (135- 147 mmol/L or mEq/L) There were no significant differences among the three subgroups in the experimental group (Table 3). The minimum physiological requirement for sodium is 500 milligrams per day and the excessive intake of sodium is associated with hypertension and swelling in the tissues (O'Shaughnessy et al., 2006).

Carbone et al. (2005) observed in their study that a short burst of intensive exercise(100-m swim lasting one minute and resulting in a 12-fold rise in the level of blood lactate) resulted in frank hypernatremia (serum sodium level greater than 145 mEq/L) in 30% to 40% of well-trained athletes. Other studies showed that the exercise induced hyponatraemia (Sodium <135 mmol/l) is the principal electrolyte disorder seen after prolonged endurance exercise (PSE), and is considered by some (Noakes et al., 1990) to be the greatest risk to athletes. A reduction in the extracellular sodium concentration will result in a fluid shift into the intracellular space, which can lead to cellular swelling and its associated complications. Hyponatraemia (Sodium <130 mmol/l) is not confined to people engaging in competitive athletic events (Noakes et al., 1990). Potassium is the major cation of intracellular fluid was measured in serum and our results showed that the serum level of K was increased significantly in all experimental groups (4.64 ± 0.57 mmol/L or mEq/L) compared to control (4.18± 0.24 mmol/L or mEq/L) even it is within normal ranges(3.5- 5 mmol/L or mEq/L). Exercise induced hyperkalaemia generally has no effect on athletes and may even be attenuated. However, hyperkalaemia may be associated with dangerous cardio-toxicity (Ledingham, et al., 1982) and arrythmogenic events in people with underlying coronary artery disease (Thomson, *et al.,* 1989) and could explain certain instances of sudden cardiac death after PSE (Ledingham, et al., 1982). The exercise induced hypokalaemia may also be associated with arrythmogenic events in people with underlying coronary artery disease (Thomson, et al., 1989). The physiological significance of the exercise induced potassium changes in healthy people seems to be small. However, this does not rule out the importance of exercise induced potassium changes in sudden cardiac death in people with underlying cardiovascular disease. As athletes are not all free of cardiovascular disease, doctors and coaches should be aware of the potential dangers of potassium shifts resulting from this form of exercise. Slight hypokalaemia has been reported immediately after a half Ironman triathlon (Welsh, et al., 1999) and an ultra-triathlon (Gastmann, et al*.,* 1998), whereas others have reported slight hyperkalaemia after a marathon (Rose et al*.,* 1970; Franz et al., 1985; Beller et al., 1975). The hyperkalaemia is thought to be due to an exercise induced shift of potassium from the intracellular to the extracellular space (Beller et al., 1975). Our results revealed that both Na^+ and K^+ concentrations in the Jordanian athletes participated in this study were higher than control group even they are still within normal values. The results in the present study allow us to conclude that the levels of the studied factors related to kidney function are elevated in Jordanian athletes com-pared to control although they are still in the normal ranges.

Conclusion

Based on the results we can conclude that the most abnormalities observed on routine biochemical screening for the factors related to kidney functions such as glucose, urea, creatinine, sodium and potassium levels among Jordanian top level athletes are of no clinical significance.

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REFERENCES

Bale P, Colley E, Mayhew J, Piper F, Ware J (1994). Anthropometric and Somatotype Variables Related to Strength in American Football Players. J. Sports Med. Phys. Fitness 34(4): 383-389.

Banfi G, Del Fabbro M (2006). Relation between serum creatinine and body mass index in elite athletes of different sport disciplines, Brit. J. Sports Med. 40: 675-678.

Beller GA, Maher JT, Hartley LH (1975). Changes in serum and sweat magnesium levels during work in the heat. Aviat. Space Environ. Med. 46: 709-12.

Carbone LD, Barrow KD, Bush AJ, Boatright MD, Michelson JA, Pitts KA, Pintea VN, Kang AH, Watsky MA (2005). Effects of a low sodium diet on bone metabolism. J. Bone Miner Metab. 23(6): 506-513.

Clarkson PM, Kearns AK, Rouzier P (2006). Serum creatine kinase levels and renal function measures in exertional muscle damage. Med Sic Sports Exec 38: 623-627.

De Voss N, Singh N, Ross D, Starriness T (2005). Optimal Load for Increasing Muscle Power During Explosive Resis-tance Training in Older Adults. J. Gerontol. (5): 638-647.

Franz KB, Ruddel H, Todd GL (1985). Physiologic changes during a marathon, with special reference to magnesium. J. Am. Coll. Nutr. 4: 187-94.

Garrett WE, Kirkendall DT (2000). Exercise and sport science. Philadelphia, PA: Lippincott, Williams & Wilkins.

Gastmann U, Dimeo F, Huonker M (1998). Ultra-triathlon-related blood-chemical and endocrinological responses in nine athletes. J. Sports Med. Phys. Fitness, 38: 18-23.

Irving R, Noakes T, Raine R, Van Zyl Smit R (1990). Transient oliguria with renal tubular dysfunction after a 90 km running race. Med. Sci. Sports and Exerc. 222: 756-761.

Ledingham I, Mac Vicar S, Watt I (1982). Early resuscitation after marathon collapse [letter]. Lancet, 2: 1096-1097.

Lippi G, Banfi G, Salvagno G, Francine M, Guidi G (2008). Glomerular Filtration Rate in Endurance Athletes [Brief Report]. Clin. J. Sport Med. 18(3): 286-288.

Malina M, Morano P, Barron M, Miller S (2005). Growth Status and Estimated Growth Rate of Youth Football Players: A Community-Based Study, Clin. J. Sports Med.15 (3): 125-132.

Manson J, Stampfer M, Graham H (2005). Diet, lifestyle, and the risk of type 2 diabetes mellitus in women. New Engl. J. Med. 345(11): 790-797.

Mayr A, Kuipers H, Falk M (2006). Comparison of hematologic data in world elite junior speed skaters and in non-athletic juniors. Int. J. Sports Med. 27: 283–288.

Mueller PJ, O'Hagan KP, Skogg KA, Buckwalter JB, Clifford PS (1998). Renal hemodynamic responses to dynamic exercise in rabbits. J. Appl. Physiol. 885: 1605-1614.

Nagel D, Seiler D, Franz H (2006). Biochemical, hematological and endocrinological parameters during repeated intense short term running in comparison to ultra-long-distance running. Int. J. Sports Med. 13: 337–374.

Nikolaidis M, Protosygellou M, Petridou A (2003). Hematologic and biochemical profile of juvenile and adult athletes of both sexes: implications for clinical evaluation. Int. J. Sports Med. 24: 506-511.

Noakes T, Carter J (1990). Biochemical parameters in athletes before and after having run 160 kilometers. S. Afr. Med. J. 6 (50):1562–1566.

O'Connor D, Crowe M, Spinks W (2006). Effects of static stretching on leg power during cycling. Turin 46(1): 52-56.

O'Shaughnessy K, Karet F (2006). Salt Handling and Hypertension. Ann. Rev Nutr. 113 (8): 1075-1081.

Perrone R, Madias N, Levey A (1992). Serum creatinine as an index of renal function. Clin. Chem. 38:1933–1953.

Poortmans J (1995). Renal clearance of plasma proteins in man during rest and exertion. Archives Internationales de Physiologie et de Biochimie 775: 346-349.

Rigalleau V, Lasseur C, Perlemoine C, Barthe N, Raffaitin C, Chauveau P, Combe C, Gin H (2003). Cockcroft-Gault formula is biased by body weight in diabetic patients with renal impairment. Metabolism 55(1): 108-112.

Rose L, Carroll D, Lowe S (1970). Serum electrolyte changes after marathon running. J. Appl. Physiol. 29: 449–451.

Russell C, Jeremy A (2007). BMI Changes in High School Football Linemen Transitioning From Senior Year to College. Proceedings of the 3rd Annual GRASP Symposium, Wichita State University

Stampfer M, Hu F, Manson J, Rimm E, Willett W (2006). Primary prevention of coronary heart disease in women through diet and lifestyle. New Engl. J. Med. 343(1): 16-23.

Thomson A, Kelly D (1989). Exercise stress-induced changes in systemic arterial potassium in angina pectoris. Am. J. Cardio, 63:1435-1440.

Welsh R, Warburton D, Haykowksy M (1999). Hematological response to the half ironman triathlon Med. Sci. Sports Exerc. 31: 63- 68.

Wilmore J, Costill D (2006). Physiology of sport and exercise. Champaign, Illinois, USA: Human Kinetics, 377-390.