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Effect of Sport Exercises on Kidney

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Abstract: Physical exercise causes changes in renal function. Changes in renal hemodynamics during exercise especially in athletes can contribute to glomerular proteinuria and hematuria. This study was performed to clarify exercise induced proteinuria and hematuria in different groups of students in Faculty of Physical Education. 100 students (50 male and 50 female) in Faculty of Physical Education at Mansoura University were included, half in 1styear and half in the 4thyear. A brief history and clinical examination was done. Urine was examined with dipstick pre and post exercise for all students. It was found that there was significant increase in hematuria, proteinuria and leucocytes in first and fourth year after exercise as compared with before it. Also, there was significant increase in these parameters in last year students as compared with those of the first year. It was concluded that Students of the fourth year have more proteinuria and hematuria than first year students and this mandates more studies in this issue and more care of the kidney in students especially those in faculties of sport education

Key words: Proteinuria · Hematuria · Physical Education · Hemodynamic

INTRODUCTION

In normal subjects, the upper limit of urinary protein excretion is 80 mg/L per 24 hours; the incidence rates for proteinuria change in children depend on age and body surface area, but proteinuria higher than 100 mg/L in adults and 140 mg/m2 of body surface area in children usually is pathological. Sixty percent of protein excretion in urine is filtered by glomeruli, while the remaining 40% is secreted into tubules. In normal subjects, physical exercise causes changes in renal function that affect electrolyte balance, acid-base balance and kidney hemodynamics [1]. The term “orthostatic proteinuria” is used to define a condition characterized by the appearance of proteinuria upon standing or with physical exercise. Exercise proteinuria is transient in nature and is not associated with a pathological condition. Changes in renal hemodynamics during exercise can contribute to glomerular proteinuria. In addition to changes in renal hemodynamics, an increase in the permeability of the glomerular capillary wall could contribute to glomerular proteinuria during exercise [2].

Hematuria is defined as more than three red blood cells per high power field. Presence of more than 50 red blood cells per microliter of urine is considered significant hematuria. Like exercise-induced proteinuria, hematuria is not rare in healthy subjects [3]. It is generally microscopic and of glomerular origin, with a certain number of dysmorphic erythrocytes, but it may occasionally be macroscopic and arise in the excretory ducts [4]. The best known model of exercise hematuria is that which occurs in athletes [5]. It was believed that dehydration can also provoke this hemolysis [6]. The exact prevalence of hematuria in adolescent athletes is not known.

So, the purpose of this study was to establish the prevalence of exercise-induced hematuria and proteinuria in groups of healthy athletic students and to investigate the role of training intensity along years by comparing exercise-related hematuria and proteinuria in two groups of students of the first and last year in Faculty of Physical Education and persistence of proteinuria and hematuria after 48 hours of exercise.

MATERIALS AND METHODS

The study was done on 100 students (50 male and 50 female) aged from17-22year old in the faculty of sport in Egypt. Their height ranges between 165-195 cm in male

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and from 155upto180 cm in female, female weight from 45 to 80 kg and male range between 60-100 kg. Half of them are in the first year and the rest are in the fourth (last) year, comparison was done between pre and post exercise (of moderate intensity and continuous for 3 hours) for each, then repeated after 48 hours.

Thorough history and physical examination that ruled out major underlying pathology in most students were done.

Urinalysis is testing of the urine. A urine sample is usually collected using the clean-catch method [7]. Urinalysis can be used to detect and measure the level of various substances in the urine, including protein, glucose (sugar), ketones, blood, urobilinogen, bilirubin, nitrite, pH, density and leukocytes. These tests use a thin strip of plastic (dipstick) impregnated with chemicals that react with substances in the urine and quickly change color.

Statistical Analysis: The variability of results was expressed as the mean ± standard error (X±S.E.). The significance of differences between mean values was determined using Mann-Whitney-Wilcoxon test for comparison between groups and differences were considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

As shown in tables 1and 2 as well as Fig. 1, there is significant increase in hematuria, proteinuria and urine alkalinity together with significant increase in leukocytes in the first and last year after exercise as compared with before it. Ketones, density and glucose are not included in tables due to their normal values and insignificant changes with exercise in first and last year students.

As shown in Tables 3and 4 in addition to Fig. 1, there is significant increase in hematuria, proteinuria and urine alkalinity together with significant increased leukocytes and insignificant changes in nitrite in students of last year as compared with those of the first year after exercise much greater than before exercise. However, after 48 hours proteinuria and hematuria disappeared in all students.

Experimental Study on Rats: In this experimental study 2.5-3 month old male Wistar rats (nearly of the same weight200-250 gm) were used. These animals were divided randomly into 2 groups, each group consists of 10 rats, the rats were provided with food and water adlibitum. The animals were heavily exercised:

- For the first group (gp.1): This exercise consisted of swimming in a deep glass container until signs of exhaustion appeared on the animal after 5-7 minutes [8].
- For the second group (gp. 2): Exercise consisted of swimming in a deep glass container three times weekly for 12 weeks for 5 minutes with increasing the duration gradually till reaching 10 minutes to avoid drowning [8].

Rats were put in metabolic cages for collecting urine then urinalysis was done using dipsticks before and after exercise then repeated after 48hours (in gp.2 urinalysis were done after the last exercise bout which done for 5-7 minutes as gp.1).

Table 1: Comparison between pre and post exercise in students of the first year

Groups		Blood Ery/ µl	Urobilinogen mg/dl	Bilirubin mg/dl	Protein mg/dl	Nitrite mg/dl	pH	Leukocytes Leuko/µl
Pre exercise	Mean	3.4	1.6	1.1	25.6	0.05	5.2	11.2
	±S.E	1.1	0.2	0.1	2.8	0.000	0.05	0.6
Post exercise	Mean	18.8	2.7	2.2	47.6	0.09	6.7	19.6
	±S.E	2.4	0.1	0.09	4.5	0.003	0.1	1.02
	P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

±S.E: standard error of the mean.

P: significance when comparing preexercise with post exercise groups.

Table 2: Comparison between pre and post exercise in students of the last year

Groups		Blood Ery/ µl	Urobilinogen mg/dl	Bilirubin mg/dl	Protein mg/dl	Nitrite mg/dl	pH	Leukocytes Leuko/µl
Pre exercise	Mean	87.4	2.3	3.1	36.8	0.08	6.7	21.1
	±S.E	14.7	0.1	0.1	3.9	0.003	0.1	0.9
Post exercise	Mean	190.8	3.8	3.6	60.2	0.09	7.3	45.4
	±S.E	13.6	0.1	0.1	5.1	0.003	0.09	3.6
	P	<0.001	<0.001	0.001	<0.001	<0.01	<0.001	<0.001

±S.E: standard error of the mean.

P: significance when comparing preexercise with post exercise groups.

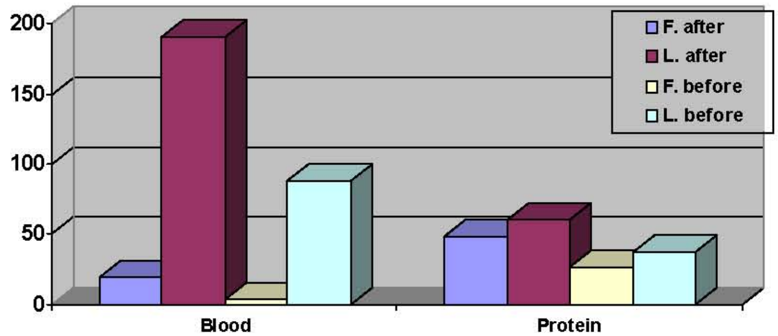

Fig. 1: Comparison between students of the first and last year before and after exercise

Table 3: Comparison between students of the first and last year before exercise

Groups		Blood Ery/ µl	Urobilinogen mg/dl	Bilirubin mg/dl	Protein mg/dl	Nitrite mg/dl	pH	Leukocytes Leuko/µl
First year	Mean	3.4	1.6	1.1	25.6	0.05	5.2	11.2
	±S.E	1.1	0.2	0.1	2.8	0.000	0.05	0.6
Last year	Mean	87.4	2.3	3.1	36.8	0.08	6.7	21.1
	±S.E	14.6	0.1	0.1	3.9	0.003	0.1	0.9
	P	<0.001	0.001	<0.001	<0.05	<0.001	<0.001	<0.001

±S.E: standard error of the mean.
P: significance when comparing first year with last year groups.

Table 4: Comparison between students of the first and last year after exercise

Groups		Blood Ery/ µl	Urobilinogen mg/dl	Bilirubin mg/dl	Protein mg/dl	Nitrite mg/dl	pH	Leukocytes Leuko/µl
First year	Mean	18.8	2.7	2.2	47.6	0.09	6.7	19.6
	±S.E	2.3	0.1	0.09	4.5	0.003	0.1	1.03
Last year	Mean	190.8	3.8	3.6	60.2	0.09	7.3	45.4
	±S.E	13.6	0.1	0.1	5.1	0.003	0.09	3.6
	P	<0.001	<0.001	0.001	N.S.	N.S.	<0.001	<0.001

±S.E: standard error of the mean.
P: significance when comparing first year with last year groups.
N.S.: non significant.

Table 5: Effect of training on exercise induced hematuria and proteinuria in rats

	Hematuria (mean score)		Proteinuria (mean score)	
Groups	Pre exercise	post exercise	Pre exercise	Post exercise
Gp.1 (n=10)	Neg.	+2	Neg.	+3
Gp.2 (n=10)	+1*	+3	+1	+4
P1	-	0.004	-	0.004
P2	-	0.007	-	0.004
P3	0.002	0.006	<0.001	0.007

*means that this result only in 7 of the rats and 3 of them gave 0 score
P1 significance when comparing pre exercise with post exercise in gp.1
P2 significance when comparing pre exercise with post exercise in gp.2
P3 significance when comparing gp.1 with gp.2

Statistics: Results were statistically analyzed by Wilcoxon-Signed Rank test to compare between post and pre exercise. Also, results were analyzed by Mann-Whitney Test to compare between the two groups for each parameter. Data considered significant if $p<0.05$.

The degree of proteinuria indicated by a change in colour of the reagent, ranging from trace (0.5-2 g/L) to 4+ (>> 20 g/L). A value of 1+ or greater corresponds to a protein concentration of at least 3 g/L and is generally considered to be "positive.

Table 5 shows that first group before exercise is negative in hematuria and proteinuria. On contrast to second group which shows positive score in both hematuria (except for 3 rats which are negative) and proteinuria. But after exercise the results are positive in both groups and second group shows more significantly increase in hematuria and proteinuria than the first group. But after 48 hours from the exercise tested parameters return normal.

DISCUSSION

We aimed by this experimental group to justify all parameters like diet habits and type, weight, age, type of exercise, duration of exercise and their effort.

We found that there is significant increase in hematuria, proteinuria and urine alkalinity together with significant increase in leukocytes in students of first and last year after exercise much greater than before exercise. Robertshaw *et al.* [9] state that exercise-induced proteinuria is strictly related to exercise intensity rather than exercise duration, although it was not observed in some subjects even after strenuous exercise. Increase proteinuria after exercise coincide with previous studies [5, 10] who gave an explanation by reduction in the normal rate of removal or reabsorption of protein from the renal tubule, which is termed "tubular proteinuria". Tubular proteinuria is characterized by the presence of low-molecular-weight proteins in postexercise urine, as lysozymes and beta-2-microglobulin, which are usually filtered at glomerular level and subsequently reabsorbed at tubular level. This is due to saturation of reabsorbing mechanisms, following a higher quantity of proteins filtered at glomerular level. Among immunoglobulins, IgA and IgG and rarely IgD, are excreted as entire molecules into postexercise urine [11]. It has been observed that exercise, by means of metabolite production, interferes with electrostatic glomerular barrier thus facilitating macromolecular filtration. Suzuki and Ikawa [12] demonstrated that increased lactate output following strenuous exercise may result in the excretion of both albumin and low molecular-weight proteins. They also observed that increased organic acid output and/or decreased renal circulation due to organic acids may change glomerular permeability and may inhibit the tubular absorption of low-molecular weight protein.

Also, Gündüz *et al.* [13] and Koçer *et al.* [14] found that in humans, exercise-associated decrease in renal plasma flow exceeds the decline in glomerular filtration rate (GFR), thus an increase in filtration fraction occurs. An increased filtration fraction could increase the glomerular filtration of moderate to large plasma proteins, such as albumin and immunoglobulin G. This is termed "glomerular proteinuria", which could contribute to an increase in the excretion of albumin that comprises the greatest proportion of excreted proteins (albuminuria) Ferris *et al.* [15].Glomerular basement membrane permeability to high-molecular-weight proteins can be altered by decreased surface anionic charges, due to both organic acid hyper production and decreased pH [12].

From a qualitative point of view, exercise induced proteinuria is mixed glomerular and tubular and occurs in case of increased glomerular permeability and partial inhibition of protein tubular reabsorption. In particular, during mild to moderate exercise, a type of mainly glomerular proteinuria can be observed, while during strenuous exercise, a mixed type of proteinuria (glomerular and tubular) can occur. Glomerular proteinuria is characterized by urine protein components following exercise that are much more similar to plasma proteins rather than to normal urine proteins at rest [16].

Increase of hematuria after exercise agrees with Paolo *et al.* [17] who stated that it is probably caused by renal ischemia and stress during exercise due to vasoconstriction of the splenic and renal circulation, with redistribution of flow to skeletal muscles. There is also an increase in intraglomerular pressure caused by angiotensin-dependent vasoconstriction of the efferent arteriole [18] and an increase in the permeability of the glomerular barrier caused by stress-related cytokine release [19]. Another possible cause of exercise hematuria is extra renal, due to repeated traumatic impact of the posterior wall of the bladder against the base [20].

Several results demonstrating renal dysfunction and the reactive oxygen stress substrates (ROS) generating effect of heavy exercise on kidneys were disregarded and these detrimental effects of exercise on renal functions were accepted as non pathological benign processes as in Koçer *et al.* [14]. Although, the kidneys of exercisers suggested being more resistant to subsequent attacks and the renal functional capacity of trained athletes would be greater than those having a sedentary lifestyle. On the other hand, the high prevalence of exercise-induced proteinuria and hematuria in athletes [2] undermines the clarity of the consensus about the risk or benefit of heavy muscle activity on kidney functions, remain to be studied.

Also, we found that there is significant increase in hematuria, proteinuria and urine alkalinity together with significant increased leukocytes in students of last year as compared with those of the first year which suggests a cumulative effect of exercise on the kidney and we hope a future plan for a study after 3 years on the same sample used for this study when they reach the fourth (last) year in the faculty of sport education, also GIT study to be included.

RECOMMENDATION

More care for the kidney of students in the faculties of sport education such as: Rest between exercises, regular evacuation of bladder and hydration which coincides with Ubels *et al.* [21] who stated that it is helpful to prevent bladder contusion due to indirect trauma from jarring movement and they also stated that if hematuria and proteinuria remained after 48 hours, they should undergo further workup in consultation with a nephrologist.

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