Original Article

Urinary Biochemical Responses to Hypogravity as Simulated by Dry Flotation

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Urinary changes in Catecholamine (CA), Vanillyl Mandelic Acid (VMA), 17-Oxogenic steroids (17-OGS) and total loss of Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}, and Pi were assessed after 6 and 12 hours of dry flotation (DF) and were compared against the control values of these biochemical variables obtained after 6 and 12 hours of normal sedentary activity. A significant change in the adrenocortical and sympathoadrenal activity was observed after 6 and 12 hours of DF. The total urinary loss of Na^{2+}, Ca^{2+}, Mg^{2+} were significantly higher after 6 and 12 hours of DF. The total urinary loss of K^{-} and Pi observed after 12 hours of DF were also high. The mechanism of these changes could be explained by redistribution of body fluid and altered hormonal mechanism as observed during other ground based simulation studies of weightlessness.

Key words : Weightlessness, Urinary Catecholamine, mineral excretion.

Exposure of man to weightlessness as encountered in orbital flight has revealed a series of alterations in fluid, electrolyte, mineral metabolism and hormonal activity[1,2]. Much of our knowledge concerning the mechanism of these changes has been acquired through the ground based simulation studies; prominent among them are -6° head down tilt (HDT), head out water immersion, bed rest and immobilisation[3-8]. Soviet Scientists have employed a dry flotation (DF) technique in which subjects are protected from water contact by a thin plastic sheet[9]. This has been reported to represent an ideal analog of microgravity since it has been demonstrated that the physiological changes related to fluid redistribution endure longer when condition of weightlessness is induced by DF[9]. This study reports changes in the urinary fluid volume, electrolyte and mineral excretion and urinary catecholamine and Oxogenic steroid (17 OGS) excretion after exposure to 6 and 12 hours of DF as against those noted during normal sedentary activity of similar duration.

Material and Methods

The subjects in this study were eighteen healthy males (Age: 21.3 ± 3.7 yrs; Ht : 167.5 ± 9.8 cm; Wt : 64.2 ± 9.8 Kgs). Ten of them were subjected to DF for 6 hours (0700 hours to 1300 hours) and the other eight subjects were exposed to DF for 12 hours (0800 hours to 2000 hours). On the day of experiment subjects reported to the laboratory after breakfast. Subjects emptied their bladder completely and were asked to lie supine on the raised platform of DF tank for 30 min before being subjected to DF by lowering the platform into the tank. The detail of DF facility designed and developed at this Institute is reported earlier[10]. Similar fluid and food regime were maintained during DF and control study ie, normal sedentary activity. Subject's urine samples were collected during DF and normal sedentary activity of similar duration in a clean urine collecting jars, pooled and the volume measured. An aliquot was preserved in 6N HCL and refrigerated. Urine samples were analysed for Na^{+}, K^{+} by Flame photometry, Ca^{2+}, Mg^{2+}, Inorganic Phosphate (Pi), creatinine, 17-OGS, Epinephrine (E), Norepinephrine (NE), and Vanillyl Mandelic Acid (VMA) by standard procedures[11]. All the urinary values were expressed as creatinine based ratio since this reduces error due to the differences in timing of urine collections and bladder emptying[12,13].

Results

As compared to control, urinary Volumes were significantly higher both after 6 and 12 h of DF. Total urinary creatinine values obtained after 6 and 12 h of DF were not significantly different from their control values. Changes in urinary Na^{+}, Ca^{2+}, Mg^{2+} were significantly higher both after 6 and 12h of DF, while the changes in K^+ and Pi were significant after 12h of DF (Table-I).

Table I : Urinary Na^+, K^+, Ca^{2+} , Mg^{2+}, Pi (mmol/100 µmol creatinine), Creatinine (mmol) and urinary Volume (ml) changes following 6 hour (n=10) and 12 hours (n=8) of dry flotation (mean ± SEM).

	Control	DF (6h)	Delta	p
Na^+	0.990±0.109	1.530±0.134	0.540±0.141	<0.01
K^+	0.476±0.049	0.577±0.059	0.101±0.044	NS
Ca^{2+}	0.0172±0.0025	0.031±0.007	0.0136±0.005	<0.05
Mg^{2+}	0.0723±0.0087	0.093±0.0092	0.0212±0.0084	<0.05
Pi	0.335±0.046	0.357±0.059	0.026±0.049	NS
Creat-ininn	4.420±0.250	3.870±0.196	-0.549±0.297	NS
Urinary Volume	447±59.2	831±67.4	384±37.2	<0.001

	Control	DF (12h)	Delta	P
Na^+	0.625±0.129	1.210±0.250	0.575±0.230	<0.05
K^+	0.183±0.034	0.264±0.044	0.081±0.029	<0.05
Ca^{2+}	0.016±0.003	0.032±0.069	0.016±0.006	<0.05
Mg^{2+}	0.046±0.009	0.069±0.009	0.023±0.009	<0.05
Pi	0.158±0.048	0.296±0.074	0.138±0.041	<0.05
Creat inine	12.370±3.280	11.050±2.920	-1.32 ±3.860	NS
Urinary Volume	648.8±92.4	1010±150.9	307.2±108.6	<0.01

Increase in urinary 17-OGS were significant during 6 h of DF but the subsequent rise observed after 12 h of DF were not. No significant changes were observed in the urinary excretion of E, NE after 6 and 12 h of DF, while the rise in the urinary VMA were significant both after 6 and 12 h of DF (Table II).

Discussion

In the present study, significant increase in urine volume was observed both after 6 and 12 h of DF as compared to the control values. The magnitudes of increase in urine volume were however not significantly different under the two conditions of DF. The pronounced diuresis observed in this study were similar to those reported after HDT[3] and head out immersion experiments[5]. Cephalad fluid redistribution leading to simulation of atrial volume receptors and reflex supression of ADH secretion have been quoted as the possible mechanism for increased fluid loss[3,14].

Table II: Urinary Epinephrine (E), Norepinephrine (NE) (nmol/100 µmol creatinine), Vanillyl Mandelic Acid (VMA), 17-Oxogenic steroids (17-OGS) (mol/100 µmol creatinine) changes following 6 h (n=10) and 12 h (n=8) of dry flotation (mean ± SEM).

	Control	DF (6 h)	Delt	p
1. E	0.163±0.040	0.246±0.047	0.083±0.087	NS
2. NE	0.620±0.149	0.740±0.139	0.120±0.199	NS
3. VMA	0.078±0.007	0.106±0.012	0.028±0.009	<0.02
4. 17-OGS	0.332±0.044	0.465±0.044	0.132±0.069	<0.05

	Control	DF (12 h)	Delta	p
1. E	0.220±0.077	0.910±0.330	0.690±0.338	NS
2. NE	0.640±0.155	3.640±2.280	2.990±2.260	NS
3. VMA	0.035±0.005	0.075±0.016	0.040±0.016	<0.05
4. 17-OGS	0.187±0.026	0.363±0.109	0.176±0.125	NS

The values of Na^+ excretion were found to be significantly elevated during 6h of DF. During 12h of DF both Na^+, K^+ excretion values were found to be significantly elevated. The magnitude of percentage rise of Na^+ excretion were found to be significantly higher at 12h of DF as against those noted during 6 h of DF. The rise in the level of Na^+ excretion observed after 6 and 12 h were similar to those reported during HDT[3,4], head out water immersion[5]. A diminution in aldosterone secretion has been reported during HDT[3], water immersion[5] and space flight[1,2]. In space flight natriuresis can be seen even when aldosterone is increased[1]. Further, involvement of increased secretion of atrial natriuretic factor (ANF)[3], and diminution in the activity of angiotension II and ADH, which are known for Na^+ retaining activity, have also been implicated[5,12]. Kaliuresis observed after 12 h of DF suggests increased activity of aldosterone. However continued natriuresis even at 12 h of DF appear to be infuenced by a predominating action of ANF.

A good correlation has been reported to exist between Ca^{2+} and Na^{+} excretion ie whenever there is increased natriuresis there will be increased calciurea also[15]. This suggest involvement of a third factor probably as a result of apparent plasma volume expansion which inhibit the reabsorption of Ca^{2+}, if there is a large excretion of Na^{+}.[16] Loop diuretics for example furosemide provides another example of correlation between Na^{+} and Ca^{2+}. This inhibits the active reabsorption of Na^{+} and Cl^{-} in the thick ascending limb which will probably impair the formation of lumen positive transepithelial potential difference thereby impairing the Ca^{2+} absorption[17].

Renal handling of Mg^{2+}, is poorly understood. However changes in Mg^{2+} excretion parallels that of Ca^{2+} [18]. In this study, the changes in the urinary excretion of Mg^{2+} both during 6 and 12 h of DF were similar to those of Ca^{2+} and may be explained on the similar basis. The significant increase seen in the excretion of Pi at 12 h of DF may also be due to the apparent plasma volume expansion or as a result of third factor effect[19].

In a recent study conducted by Arnaud et al[4] who used a -6^{0} HDT model for simulating the effect of microgravity reported a significant increase in the urinary excretion of Na^{+} and Ca^{2+} on the Ist day, Pi on 6th day, and reduction in serum PTH and 1-25 dihydroxy Vit D on 6th and 7th day respectively. This study showed an early change in Ca^{2+} and Pi excretion but in view of the recent findings on Ca^{2+}, Pi regulating hormones do not suggest an early bone demineralization but may be an early ion flux associated with cephalad fluid shift leading to an altered renal handling of these Ions.

Urinary 17-OHCS level showed a marked reduction during space flight but a significant rise was reported on the first day post flight[1,2]. During bed rest, blood levels of ACTH was seen to increase gradually[7]. In the present study, a significant rise in the urinary excretion of 17-OGS was observed after 6h of DF which could be due to an early rise of ACTH secretion but subsequent rise observed after 12h of DF was not significant.

Exposure to weightlessness is accompanied by marked reduction in the activity of sympathetic nervous system and catecholamine release[1-3]. It is reported that a decrease in sympathetic activity is associated with increased incidence of orthostatic hypotension[3].

A decrease in plasma level of NE was noted at day 7 of HDT and remained so during the entire period of 30 day exposure[3]. In the present study urinary excretion of E and NE remained unchaged after 6h of DF and showed a rise at 12 h of DF, though not statistically significant. These indicated that there was no reduction in the sympathetic activity during the early hours of exposure to DF.

Changes in urinary excretion of VMA indicate the activity of the sympathoadrenal systems. A significant increase in VMA excretion has been reported after 2 and 4 h of head out water immersion[5]. In the present study, VMA excretion showed an increase after 6 h of DF which showed further increase at 12 h. These VMA changes as well as the changes in E, NE excretion do not suggest a decreased sympathetic activity during this period of observation.

To conclude, present observations of the urinary excretion pattern of Na^{+}, K^{+}, Ca^{2+}, Mg^{2+} and Pi at 6 and 12 h of DF suggest that the urinary loss of these are significantly increased during early hours of DF. Eventhough the magnitude of these changes were not similar to those reported during space flight and other long term ground based simulation studies, the changes were in the similar direction and are indicative of early effects of weightlessness. The changes in the urinary levels of E, NE and VMA observed after 6 and 12 h are suggestive of an increased sympathoadrenal activity during the observed period of DF.

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