## 11210 P

# Potassium Exchanges in Man in Brief Exercise.

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Severe muscular exercise produces a rise in plasma potassium (Ewig and Wiener,[1] Baetjer,[2] Keys[3]). A loss of potassium from the muscle associated with muscular activities can be proved under some conditions (Fenn[4]). Does it follow that muscular contraction always involves a loss of potassium from the muscle to the blood stream? Extreme or unphysiological conditions are required to give a positive answer from tissue analyses. Blood sampling studies have not ruled out the red cells as a source of potassium in the immediate changes resulting from brief exercise in man. Calculations from whole blood and plasma are inadequate because of analytical limitations.

Major changes of plasma [K] occur within the exercised region in man at a time when products of metabolism like lactate are only beginning to enter the plasma. Table I gives results from a typical experiment.

We have attempted to evaluate the rôle of the red cells in the K exchanges in young men exercised by violent running in place for 40 to 60 seconds. Blood samples were drawn under oil from an antecubital vein before and within a few seconds of the end of exercise. The heparinized samples were immediately centrifuged in long centrifuge tubes under oil at 2 to 5°C. After

TABLE I.

Plasma concentration in a young man after 55 seconds of running at top speed. Protein as g protein nitrogen per kg of water, K, Na, and lactate, as milliequivalents per kg $H_2O$. Times at approximate mid-point of withdrawal of sample.

| Time after end of exercise, sec | Arterial plasma | | | | Femoral vein plasma | | |
|---|---|---|---|---|---|---|---|
| | Lactate | Protein | K | Na | Protein | K | Na |
| Rest | 9 | 1.04 | 4.75 | — | — | — | — |
| 35 | 29 | 1.18 | 5.31 | 150.1 | 1.16 | 5.97 | 156.7 |
| 52 | — | — | — | — | 1.22 | 6.11 | 153.5 |
| 78 | 98 | 1.20 | 5.88 | 152.6 | 1.09 | 6.04 | 149.2 |
| 390 | 126 | — | 5.24 | — | — | — | — |

1 Ewig, W., and Wiener, R., *Z. ges. exp. Med.*, 1928, **61**, 562.

2 Baetjer, A. N., *Am. J. Physiol.*, 1935, **112**, 139.

3 Keys, A., *Trans. Faraday Soc.*, 1937, **33**, 930.

4 Fenn, W. O., *Physiol. Rev.*, 1936, **16**, 450.

TABLE II.

Analytical results from a typical experiment in which a young man exercised by standing running at top speed for 55 seconds. The "work" sample was drawn over the period between 20 and 70 seconds from the end of exercise. Concentrations of K, Total Base, and Na in terms of milliequivalents per kg of water of the cells and plasma respectively.

| Condition | Cell vol., % | Water, g/kg | | K | | Total Base | | Na |
|---|---|---|---|---|---|---|---|---|
| | | Plasma | Cells | Plasma | Cells | Plasma | Cells | Plasma |
| Rest | 43.2 | 923.9 | 666.4 | 4.95 | 135.7 | 154.4 | 164.6 | 148.8 |
| Work | 46.5 | 916.8 | 672.2 | 6.02 | 130.0 | 163.2 | 157.4 | 156.8 |
| Δ | +3.3 | —7.1 | +5.8 | + 1.07 | —5.7 | +8.8 | —7.2 | +8.0 |
| Δ, as % of Rest, | +7.6 | —0.77 | +0.86 | +21.6 | —4.2 | +5.7 | —4.4 | +5.4 |

50 minutes at 2800 r.p.m. the oil was removed and the middle portion of the plasma taken for analysis. The remaining plasma and the top 0.5 cm of cells were removed and then the cells were sampled by syringe-pipettes (Krogh and Keys[5]). Plasma and cells were analyzed separately for water (drying at 105°C), total base (Keys[6]) and potassium (Hartzler[7]). Duplicates were run on all except K which was analyzed in triplicate. Results from a typical experiment are summarized in Table II.

Table II shows that [K] in the plasma rose 21.6%, but that apparently more than this change could be accounted for by loss from the red cells. More exact comparison requires allowance for the volumes of water and their alterations in the red cells and plasma. When correction is made for the water imbibed by the red cells, the net changes in K and total base per kg of red cell water become − 2.2 and − 2.9 m.eq. respectively, corresponding to losses from the red cells of 0.63 and 0.83 m.eq. per kg of whole blood. There is a gain of 1.07 m.eq. K per kg water by the plasma, or a gain of 0.52 m.eq. per kg of whole blood. The red cell loss of K is still greater than the plasma gain.

Further indication that no large net gain of whole blood K occurs immediately in brief exercise is found when the plasma concentration is considered in more detail. If the red cells were impermeable to K and there were a high K gradient from the muscle to the blood side of the capillary wall, then the water which is drawn to the muscles and red cells by osmotic forces in brief exercise should carry no K and the remaining plasma should have an elevated [K] from this reason alone. When correction is made for the water loss from the plasma on this basis the net increment of K is only + 0.27 m.eq. per kg of original whole blood.

5 Krogh, A., and Keys, A., *J. Chem. Soc.* (Lond.) 1931, **1931**, 2436.

6 Keys, A., *J. Biol. Chem.*, 1936, **114**, 449.

7 Hartzler, E., *J. Biol. Chem.*, 1937, **122**, 19.

The findings discussed here are typical of experiments on 5 subjects. It is possible that the red cell-plasma K exchanges may have occurred *in vitro* in spite of our care. Such an effect could not, however, have masked any appreciable true gain of "foreign" potassium.

There is another possibility—new red cells low in potassium could have been added to the blood stream from the spleen or some other reservoir. It can be calculated that these "new" red cells would have to contain the extraordinarily low concentration of 105 m.eq. K/kg $H_2O$ to account for the red cell values found.

There is no doubt that potassium enters the blood from the muscles when longer periods of exercise are used. It may be that even in these short periods of exercise K enters the blood from the muscle, but if so it must be removed elsewhere, perhaps in the liver, at an equal rate.

## 11211

## Prevention of Histamine and Surgical Shock by Cortical Hormone (Desoxycorticosterone Acetate and Cortin) and Saline.

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It is well established from pathological and experimental studies that the suprarenal cortex plays a significant rôle in the mechanism of natural resistance to intoxications, poisons, shock and bacterial and protozoan infections.* The similarity between adrenal insufficiency and the condition of secondary shock has been emphasized by many investigators.[3, 4, 5] The therapeutic effect of cortical hormone in the prevention of anaphylactic shock in guinea pigs[6] and in shock due to intestinal obstruction in dogs[7] has been reported.

It was observed that parenteral administration of large amounts of physiological saline given some hours prior to the production of

* This subject is reviewed by Perla and Marmorston.[1,2]

1 Perla, D. and Marmorston, J., *Arch. Path.*, 1933, **16**, 379.

2 Perla, D., and Marmorston, J., *Natural Resistance and Clinical Medicine*, Little, Brown and Co., Boston, Mass., 1940, in press.

3 Sweet, J., *Am. J. M. Sc.*, 1918, **155**, 627.

4 Swingle, W. W., Pfiffner, J. J., Vars, H. M., Bott, P. A., and Parkins, W. M., *Science*, 1933, **77**, 58 (includes review of literature).

5 Zwemer, R. L., and Scudder, J., *Surgery*, 1938, **4**, 510.

6 Wolfram, J., and Zwemer, R. L., *J. Exp. Med.*, 1935, **61**, 9.

7 Heuer, G. J., and Andrus, W. de W., *Ann. Surg.*, 1934, **100**, 734.