THE EFFECT OF THE DRINKING PATTERN ON WATER ECONOMY IN HOT, HUMID ENVIRONMENTS

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(RECEIVED FOR PUBLICATION SEPTEMBER 11, 1953)

Work in a hot, humid environment, whether in some unfavourable industrial situation in the temperate zone or in a tropical climate, involves the worker in a high rate of water loss by sweating. Since any marked degree of water debt is undesirable, if only from the subjective aspect, provision must be made for water replacement.

A man's drinking pattern is conditioned by two main factors, the thirst mechanism and the availability of water. The thirst mechanism is notoriously inadequate since it has been demonstrated (Adolph, 1947) that even when exposed to an unlimited supply of water a man may contract a water debt amounting to about three-quarters of a litre, the phenomenon of "voluntary dehydration". When the water supply is limited the problem is complicated by the fact that the most economical use must be made of the available supply. If large volumes of water are drunk at any one time a water diuresis will result and the excess water excreted through the kidney is thereby lost to the more desirable route of evaporation through the skin by which heat may also be dissipated.

The experiments described in this paper were made to determine the most economical way physiologically of administering a water ration to a group of men exercising in an environment representative of the climatic conditions found in a deep mine in Nigeria (Ladell, 1951).

The six subjects were typical members of the Lagos labour force who had been trained to empty the bladder completely at frequent intervals without recourse to catheterization. They exercised in a climatic chamber maintained at a temperature of 100° F. dry bulb, 93-5° F. wet bulb, by stepping on and off a stool 12 inches high 20 times per minute for five minutes in each quarter of an hour. The air movement in the chamber was turbulent and at a rate of less than 50 feet per minute. One experiment was performed at each drinking pattern and the exposures were spaced at least one week apart in order to avoid the risk of the subjects becoming acclimatized to the experimental conditions.

In each experiment the total exposure consisted of six cycles of work and rest, 90 minutes in all. The men were weighed at the start of the experiment immediately after emptying the bladder, and at the end of each of the six cycles the following measurements were made: (1) The men were dried with a towel to remove unevaporated sweat and then weighed. (2) The men emptied their bladders and the volume of urine excreted was measured. (3) Rectal temperatures were taken.

During a preliminary experiment it was found that when no water was drunk the men, at the end of the experiment, were approximately 1 kg. lighter than at the start of the exposure, i.e., they had contracted a water debt of about 1 litre, since under these circumstances almost the entire weight loss was due to urinary or cutaneous excretion of water.

It was decided, therefore, to adopt a volume of 1 litre of water as the fluid ration for this exposure and to administer this volume in various ways in order to decide which fashion of administration was the most economical. The desirable pattern is presumably the one which provokes the least diuresis and enables the man to finish his spell of work at the same body weight as that at which he began.

The patterns of water administration were (a) 1,000 ml. at the start of the experiment, (b) 333 ml. at the start of the experiment and two further doses of 333 ml. at intervals of 30 minutes, (c) 167 ml. at the start of the exposure and every subsequent
DRINKING PATTERN IN HOT, HUMID ENVIRONMENTS

WATER BALANCE STUDIES FOR 90 MINUTES OF MEN WORKING (STEP-CLIMBING) IN A HOT, HUMID ENVIRONMENT

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Drinking Pattern</th>
<th>Water Debt (ml.)</th>
<th>Water Turn-over (ml.)</th>
<th>Urine Loss (ml.)</th>
<th>Non-urinary Loss (ml.)</th>
<th>Change in Rectal Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>None</td>
<td>1,026 ± 153</td>
<td>1,026 ± 153</td>
<td>81 ± 17</td>
<td>945 ± 174</td>
<td>3.66 ± 0.60</td>
</tr>
<tr>
<td>a</td>
<td>1 dose of 1,000 ml.</td>
<td>646 ± 218</td>
<td>1,446 ± 218</td>
<td>371 ± 207</td>
<td>1,075 ± 74</td>
<td>3.18 ± 0.17</td>
</tr>
<tr>
<td>b</td>
<td>3 dose of 333 ml.</td>
<td>369 ± 123</td>
<td>1,369 ± 123</td>
<td>227 ± 82</td>
<td>1,142 ± 112</td>
<td>3.20 ± 0.22</td>
</tr>
<tr>
<td>c</td>
<td>6 dose of 167 ml.</td>
<td>215 ± 111</td>
<td>1,215 ± 111</td>
<td>170 ± 49</td>
<td>1,045 ± 60</td>
<td>3.10 ± 0.60</td>
</tr>
<tr>
<td>d</td>
<td>12 doses of 83 ml.</td>
<td>100 ± 109</td>
<td>1,100 ± 109</td>
<td>82 ± 29</td>
<td>1,018 ± 88</td>
<td>2.90 ± 0.30</td>
</tr>
</tbody>
</table>

The fact that a man takes his water ration in frequent small doses leads to a saving of between 300 and 400 ml. of water during the 90-minute period. The saving over a whole eight-hour shift spent at these temperatures will be considerable and in circumstances where the water supply is limited may make the difference between the man's being able or not to finish his shift.

It is probably impossible to achieve the ideal condition of very frequent drinking in the average industrial situation as the process is tedious but these results emphasize the need for a freely available supply of water in hot industrial situations and for the education of the worker in the habit of more frequently drinking smaller volumes.

Summary

Experiments on the male West African exercising in a hot, humid environment similar to that found in the mines of this area have demonstrated that a considerable saving in water required by the subjects can be effected if small volumes are taken at frequent intervals rather than large volumes taken less frequently. This finding may be of considerable importance in situations where the water supply is limited.

The author is indebted to Dr. D. W. Horn, Statistician to the Department of Medical Services, Nigeria, for the statistical examination of the results.

References


15 minutes, *(d)* 83 ml. at the start of the exposure and every subsequent seven and a half minutes.

Results

In the Table are recorded mean values and standard deviations for the following functions: (1) Water debt, i.e., the difference between the initial and final weights expressed in terms of millilitres of water; (2) the water turn-over, the water debt plus the volume of water taken during the experiment; (3) the volume of water excreted in the urine; (4) the non-urinary loss of water, calculated from the water turn-over minus the urinary loss; (5) the change in rectal temperature during the exposure.

It will be observed that in the case of all drinking patterns except (d) the volume of urine excreted is greater than that excreted during the control experiments when no water was taken. Statistical analysis of these values reveals significant differences at the level of P<0.01. There is also a significant difference between the water debt values obtained in the control experiments and in patterns (a), (b), and (c). There is no significant difference between the values for non-urinary water loss in the various experiments.

Discussion

These results indicate that when water is taken in volumes greater than about 100 ml. at one dose a significant diuresis results leading to a greater loss of body water during the experimental exposure. If a man, therefore, is to use a water ration to the greatest advantage he must drink small volumes frequently rather than larger volumes at longer intervals.
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doi: 10.1136/oem.11.1.38

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