

DEHYDRATION AND REHYDRATION OF COAL MINERS DURING WORK AT HOT WORKING PLACES

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INTRODUCTION

In German hard-coal mining, the mining depth has increased to a current mean of **970** m. With our fully mechanized coal extraction, a great amount of electrical power is utilized. Additionally, a considerable volume of water has to be sprayed when cutting coal and rock to prevent the development of dust. As a result, many miners are working in warm or hot climatic conditions. Before descending, the miners may obtain drinks (e.g., fruit tea) from automated supply stations provided by the employer. In order to improve the advice given to miners with respect to drinking behavior, we performed a field study on dehydration and rehydration.

MATERIALS AND METHODS

Measurements were taken during mining operations, including 85 working shifts of 30 miners (age: 34 ± 5 years; body mass: 85 ± 12 kg; height: $1.77 \text{ h} 0.77$ m; [mean \pm standard deviation]). Heart rates, as well as body temperatures, were measured throughout the shifts. Body mass loss and amounts of fluid intake, food consumption and urine excretion were recorded. Fluid content of the ingested food (1) and fluid loss from urine were included into the calculation of sweat loss. Basic Effective Temperature (BET; [2]) at the different working places varied from BET 16°C to BET 33°C . The time spent at the working site was about 5 hours.

RESULTS

Heart rate and body temperatures did not show a significant increase with climatic stress at the different working places—we assume that the miners adjust their work intensity according to their perception of strain in order to cope with heat stress. Sweat loss, as well as amounts of fluid consumed, increased significantly ($P < 5 \cdot 10^{-5}$) with temperature: sweat losses increased from 1.5 kg/shift at BET 16°C to 4.5 kg/shift at BET 33°C . The data show great interindividual variation associated with different working tasks, individual physical fitness and presumably different heat tolerance and habituation to work in the heat.

Figure 1 gives the sweat loss as a percentage of body mass. The mean sweat loss values were $4.0 \pm 1.4\%$. The values exceeded 5% for a number of shifts. The maximum value of 9.7% sweat loss was recorded during a shift with hard physical work due to defective machinery. During the shifts, the miners drank 2.0 ± 0.7 kg of drinking fluid or $2.4 \pm 0.8\%$ of body mass. With respect to water balance

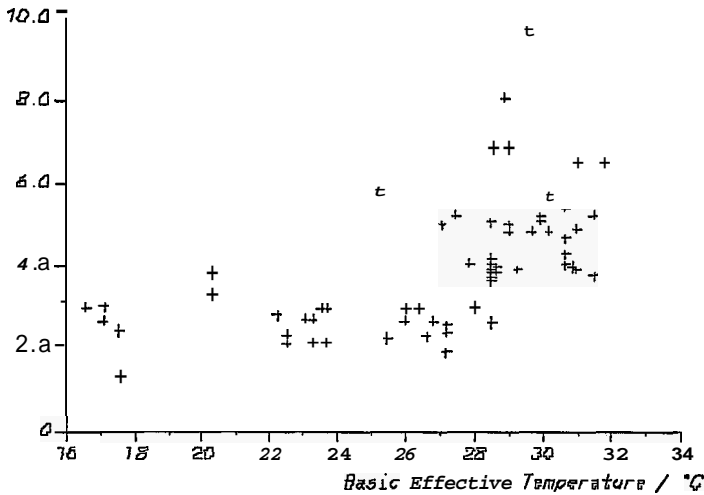


Figure 1. Percentage of sweat loss during shifts in terms of body mass as a function of increasing climatic stress.

(i.e., taking into account water uptake with food as well as urine excretion), the mean dehydration for all the **shifts** investigated resulted in $1.6 \pm 0.9\%$ of body mass; the maximum value recorded amounted to 5.1%.

Figure 2 gives the percentage of rehydration compared to sweat loss for every shift. Around BET 23°C the scattering of data points covers a range from **16%** to **113%**. The observed hyperhydration resulted presumably when the miners habitually finished their tea bottles during some shifts. At high climatic stress, the amount of rehydration was around 50% to 60% of the lost sweat.

The equipment that the miners have to carry during their way to the working place (clothing, safety boots, filter, self-rescuer, cap lamp with accumulator and **drinking** fluid [2.7 10.7 kg]) adds up to 13.6 ± 3.0 kg.

DISCUSSION

Recently, several authors have reported distinct effects of dehydration on performance and on physiological data. Sawka (3) reports increases in body temperature of 0.1°C to 0.4°C for each percent body mass of dehydration. Surveys on effects of dehydration and recommendations for replacement of fluid during physical work and heat stress can be found in references (3) through (7). Losses of performance are reported for dehydration above **2%**.

Whereas the mean net dehydration stays below this limit, a number of **shifts** show values above it. When we asked the miners if they could **drink** more fluid during their shifts, some reported that they do not want to carry more drinking fluid to their working places because of the additional **mass**; others left their tea

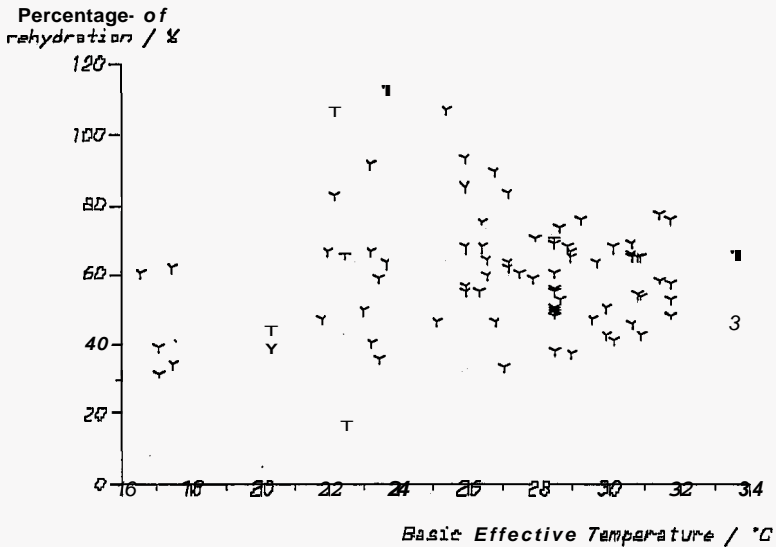


Figure 2. Percentage of rehydration compared to sweat loss during shifts as a function of increasing climatic stress.

bottles outside the coal face (in a cooler climate), and therefore had to cover some distance to reach their beverage. This made frequent drinking more difficult.

CONCLUSIONS

Working in places with **high** climatic stress, a miner may lose, depending on his physical workload, considerable body fluid by sweating. Therefore, we encourage the miners to carry a greater amount of drinking fluid with them, compared to the amount they carry now, and to frequently *drink* small amounts of fluid during their work, the latter being facilitated by carrying their drinking bottles close at hand. Additionally, we refer to the idea of preventive drinking (i.e., to start drinking even before arriving at the hot working place).

Because the necessary volume of drinking fluid depends on climatic conditions (which have a day-to-day variation due to the progress of mining) and on the physical work to be done (the intensity of physical work often depends on troubles with defective machinery), it would be desirable for the employer to supply drinking fluids at the work site.

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