STRESS AND STRAIN OF RESCUE TEAMS IN GERMAN HARD COAL MINING DURING STANDARD TRAINING PROCEDURES WITH SELF-CONTAINED BREATHING APPARATUS

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INTRODUCTION

As missions occur not too often, rescue teams need to participate in regular trainings in training galleries. There exist not many reports on strain during training of mine rescue teams (e.g. [1-5]). Stress and strain of operational rescue teams were recorded and evaluated for different types of training: a "standard training" of 120 minutes duration in a training gallery being heated up to $t_{db} = 30\,°C$, $t_{wb} = 21\,°C$, and a "training with additional climatic stress" (10 minutes inside a climatic chamber: treadmill work; $t_{db} = 40\,°C$, $t_{wb} = 30\,°C$) with a total duration of 100 minutes. The results of measurements will be compared to the demands of medical examinations of mine rescue team members.

METHOD

Heart rates and rectal temperatures were recorded on a magnetic tape recorder during the training of 10 members of operational rescue teams of the *DMT-Hauptstelle für das Grubenrettungswesen* in Essen that wore self-contained breathing apparatus (SCBA) BG 174 (Dräger, Germany). Sweat loss was measured by weighing before and after the training.

RESULTS

The 10 subjects of our investigation had a mean age (± std. dev.) of (35 ± 7) years, a body height of (180 ± 6) cm and a body mass of (82 ± 7) kg. The mass of the equipment was 14.1 kg (SCBA) plus 5.4 kg (fire resistant clothing). The length of the way inside the training gallery added to 760 m at heights down to 0.7 m. At the beginning work on a bicycle ergometer had to be done (1.2 W/kg body mass, the load being increased after 2 and 5 minutes for additional 20 W each time), and for three times during passing through the gallery 60 strokes on a weight-pull unit (≈ 400 Nm per stroke) had to be performed.

The standard training lasted for 120 minutes. Gas clock measurements for one subject showed a metabolic rate of 430 W, a ventilation rate of 30.5 l/min, and an oxygen consumption of 1.2 l/min. The mean value of heart rate during the last working period was 140 min^{-1} (95. percentile: 190 min^{-1}). 6 of the subjects had heart rates exceeding "200 - age" - a strain level that is used as a common standard during the medical examination [6] - for up to 28 % of the total duration of the training; 3 subjects exceeded a "220 - age"-level for up to 8 %. Body temperature increased monotonously during the training up to a mean value of 38.3 "C, the values of the different subjects scattering from 37.7 "C to 39.3 "C. Mean weight loss was 1910 g or 2.2 % of body weight during the training corresponding to a mean sweat rate of 908 g/h.

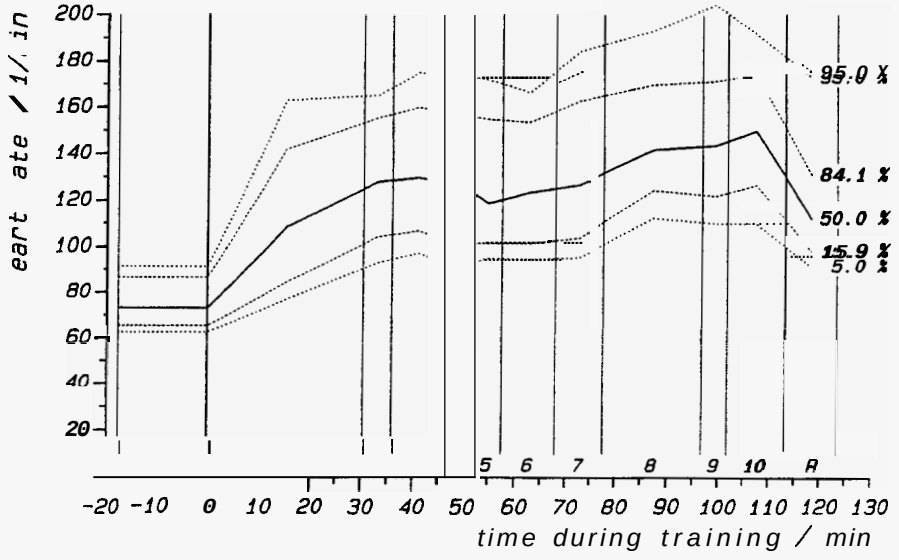

Fig 1a: Median and percentiles of heart rate of 10 subjects during the different intervals of the "training with additional climatic stress" (R: resting periods; 1: bicycle ergometer work; 8: treadmill work inside the climatic chamber; 2...7 and 9...10: training gallery).

The training with additional climatic stress had a nominal duration of 100 minutes *(550* m inside the training gallery); due to physiological measurements and some subjective ratings the actual time under exposure lasted for 113 minutes. Respiratory measurements yielded a metabolic rate of 47'0 W, a mean ventilation rate 34.4 l/min, and an oxygen consumption of 1.36 l/min. During the last working period ("10" in Fig. 1) heart rate had a mean value of 151 min^{-1} (95. percentile: 192 min^{-1}). **A** level **of** "200 - age" was exceeded by **9** out of 10 participants for **as** long **as** 55 % of the total time of the training; 4 of 10 subjects had heart rates above "220 - age" for up to 35 % of total training time. Body temperature at the end of the training period ranged from 38.3 "C to 39.7 °C with a mean value of 38.9 "C; rectal temperature increased during the exercise from 1.0 "C up to 2.3 "C (mean increase 1.4 "C); the rate of increase of body temperature varied from 0.54 °C/ h to 1.22 °C/ h. Mean weight loss was (1810 ± 680) ***g*** corresponding to a mean sweat rate of (952 ± 362) g/h. Mean dehydration amounted to 2.2 % of body mass; maximum dehydration was up to 3.5 % of body mass which is not neglible.
During the training with additional climatic stress many strain parameters are higher compared to the standard training procedure; significant increases exist for median values of heart rate ($p < .02$) and increase of rectal temperature ($p <$

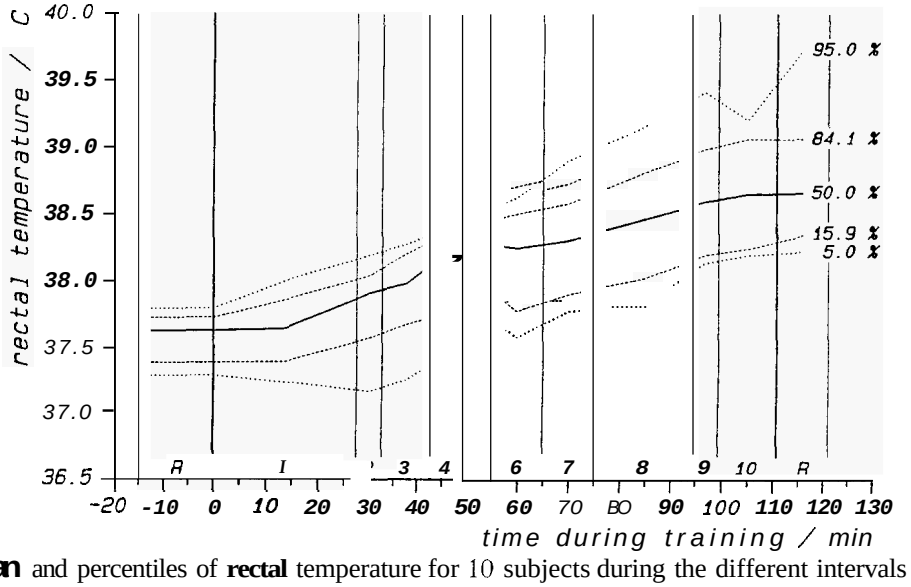

Fig Ib: **Median** and percentiles of **rectal** temperature for 10 subjects during the different intervals of the "training with additional climatic stress" (R: resting periods; 1: bicycle ergometer work; 8: treadmill work inside the climatic chamber; 2...7 and 9...10: training gallery).

CONCLUSIONS

The two types of training seem to be at the upper level of tolerable strain. In many cases heart rate exceeded the level "200 - age", which is the common standard during a maximum ergometric work at the medical examination. In consequence, during the training with additional climatic stress two working tasks have been reduced in order to reduce cardiac strain.
Another attempt to reduce strain **was** the wearing of shorts instead of long flameproof pants under fire-resistant trousers (DIN 23 320) during a standard training: mean increase of rectal temperature was lowered from 1.23 °C to 0.82 "C for a group of 5 subjects **($p < .005$)**; so the use of shorts is recommended now for all missions where it is possible with respect to safety precautions.

REFERENCES

1. Lind, **A.R.;** Hellon, R.F.; Weiner, J.S. and Jones, R.M. 1955, Tolerance of men to work in hot, saturated environments with reference to mines rescue operations, *Brit. J. Industr. Med.* 12,296-303.
2. Santostefano, V. 1975, Vergleichende Langzeit-Untersuchungen des Elektrokardiogrammes bei Grubenwehrmännern während des Einsatzes in der Übungsstrecke, Inaugural-Dissertation Essen, 1-41.
3. Bründel, K.-H. and Bussing, **A.** 1981, Energiestoffwechsel und Herzfrequenz bei Grubenwehrmitgliedern, *Zbl. Arbeitsmed.* 31, 106-112.
4. Funkemeyer, M. and Stoklossa, J. 1985, Vorbereitung der Grubenwehren auf Einsätze unter erschwerten klimatischen Bedingungen, *Glückauf* 121, 1385-1391.
5. Leigh, J.; Griffits, R.K.S. and Ellis, C.G. 1988, Respiratory enthalpy changes in mine rescue workers exercising under heat stress, *J. Appl. Physiol.* 65, 2714-2719.
6. Plan fiir die Durchführung der ärztlichen Untersuchungen im Steinkohlenbergbau 1985, (Bellmann Verlag, Dortmund).
7. DIN 23 320, 1988, Flammenschutzkleidung fiir den Bergbau (Beuth Verlag, Berlin).