Carboxyhemoglobin levels between jogging and non-jogging smokers

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Summary. The hypothesis that regular jogging diminishes blood carboxyhemoglobin levels was tested. 63 smokers were chosen, with 30 of them regular joggers for 3 years and 33 of them sedentary non-joggers. Blood samples were taken and carbon monoxide levels measured by a gas chromatograph. Results showed that smoking joggers had significantly lower carbon monoxide levels than smoking non-joggers, with values of the former comparable to non-smokers.

It is known that smokers generally have a 8–11% carbon monoxide (CO) level in circulating blood. In the work environment, the present Federal TWA (time-weighted-average) standard is 50 ppm (55 mg/m^3)[2]. The standard recommended by NIOSH (National Institute of Occupational Safety and Health) is 35 ppm with a ceiling value of 200 ppm. The latter value is to limit carboxyhemoglobin formation to 5% in a non-smoker engaged in sedentary activity at normal altitude.

CO is odorless and poisonous. It has such an affinity for hemoglobin that oxygen is displaced. If allowed to accumulate in an enclosure, CO may be fatal. Chronic CO poisoning may initiate or enhance deleterious myocardial alteration in individuals with restricted coronary artery blood flow and decreased myocardial lactate production[3,4].

A jogger was defined as one who jogged at least 3 km a day for the past 3 years, whereas a non-jogger was defined as one who never jogged and seldom exercised. By comparing joggers with non-joggers, this study attempts to test the hypothesis whether jogging has any mitigating effect on blood carbon monoxide levels.

Materials and methods. A group of 63 smokers was carefully chosen from 511 volunteers as test subjects. Among them smoking history ranged from 4 to 6 years, with a mean of 5.7 years (SD = 5.8%). The average daily cigarette intake for each indivudal was 2.9 packs (SD = 12.1%). 31 of them (49.2%) were males. Age ranged from 24 to 27 years (SD = 8.7%, $\bar{x}$ = 25.4 years). Body weights were 49.5–77.9 kg (SD = 18.2%, $\bar{x}$ = 63.3 kg). All the volunteers were of good general health. They were either full-time students or University faculty personnel.

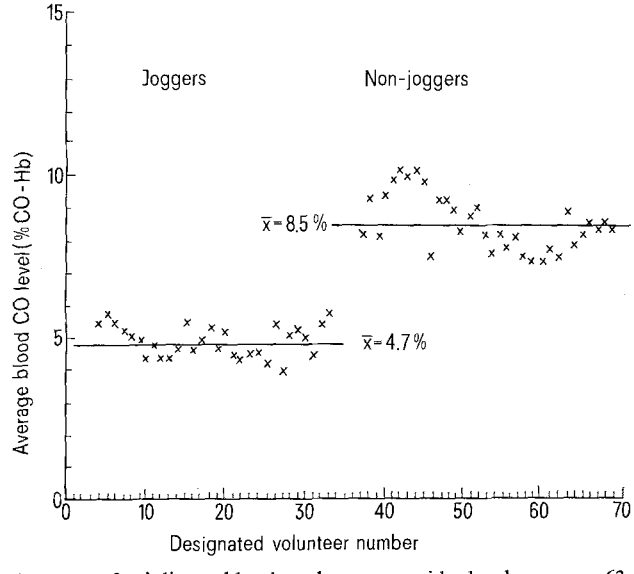
Differences between jogger and non-jogger background were minimal because of similiarities in basic characteristics such as cigarette consumption, sex ratio and age. A comparison of the 2 groups is given in the table. Informed consent was obtained from all volunteers participating in this study after the nature of the procedure has been explained.

Triplicate blood samples were obtained from each volunteer at 09.00 h, 15.00 h and 20.00 h during the weekends at least 1 h after their jogging time. The gas chromatograph method[5,6] was used to determine the blood carboxyhemoglobin level. The GC was calibrated and fitted with kathorometer detector, linear amplifier and gas-sampling valve with 0.5-ml and 5.0-ml loops. The column was 6 feet, 80-mesh, with a molecular sieve of 5 Å (steel, 1/4 inch outer diameter). The oven and detector temperatures were 110 °C and 120 °C respectively. Helium was used as the carrier gas at 45 ml/min. CO was liberated and the percent saturation calculated according to Blackmore[5] without modification. The CO readings for each volunteer were taken during normal daily activities and averaged to give a single value. Diurnal variations of carboxyhemoglobin were also obtained for 20 randomly chosen volunteers prior to the study. The levels were monitored by duplicate blood samples taken twice daily 11 h apart for a period of 7 days. Such data were used as baseline and control.

Results and discussion. The results are summarized in the figure. The sedentary non-joggers had an average carbon monoxide value of 8.5% (maximum 10.1, minimum 7.5; SD = 1.1%), as opposed to joggers with a value of 4.7% (maximum 5.8, minimum 3.9; SD = 0.3%). As aforementioned, the term non-joggers could actually be replaced by the phrase 'those who seldom exercise'. Statistical analysis using the Student t-test shows that the values are significant ($p < 0.001$). The value of 4.7% plus 2 SD gives about 5.3%. At 95% confidence, it is still below the 8.5% obtained for the non-joggers. A 'dose-response' effect was thus observed. Diurnal variations which amounted to no more than 3% of the CO value was considered negligible. In follow-up longitudinal studies, decrease in carbon monoxide levels induced by 26 weeks of 3-km daily jogging was observed in 13 individuals (formerly non-joggers). Their blood CO levels were lowered by an average of 14.6%

Comparison of basic characteristics of jogger and non-jogger groups

Basic characteristics	Joggers	Non-joggers
Sample size (N)	30	33
Mean age in years	25.1	25.6
Average daily consumption of cigarettes in packs	3.0	2.8
Sex ratio	16 males 14 females	15 males 18 females
Occupation	Full-time students and University faculty staff	
Smoking history in years	5.5	5.2



Average of triplicate blood carbon monoxide levels among 63 volunteers. The upper right scattergram denotes the blood CO levels for the non-joggers, while the lower left scattergram denotes the blood CO levels for the joggers. Diurnal variations were extremely small (< 3% of CO level), hence had practically no effect on the curves.

(SD = 3.2%). The effects of jogging could be explained by more rapid gas ecchange, increased capillary movement and adaptive carboxyhemoglobin transport to and from muscular tissue. Since the formation of carboxyhemoglobin is a reversible process, pinpointing the exact pulmonary physiological mechanisms responsible for such a lowering effect awaits further study.

Smokers usually have higher levels of carboxyhemoglobin than non-smokers (often 5–10% more). Based on this study, jogging and cigarette smoking thus seems to have antagonistic effects, with the former functionally similar to non-smoking as far as CO level is concerned. Since cigarette smoking has been documented to be linked with respiratory and cardiac problems, jogging is highly recommended for smokers as a precaution against excessive CO build-up.

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2 American Conference of Governmental Industrial Hygienists: Threshold Limit Values for Chemical Substance and Physical Agents in the Work Environment. Cincinnati, Ohio, 1980.
3 I.R. Tabershaw, H.M.D. Utidjian and B.L. Kawahara, in: Chemical Hazards in Occupational Diseases, A Guide to their Recognition. Public Health Service, National Institute of Occupational Safety and Health, 1977.
4 K. Morgan and N.L. Lapp, in: Diseases of the Airways and Lungs in Occupational Diseases, A Guide to their Recognition. Public Health Service, National Institute of Occupational Safety and Health, 1977.
5 J.D. Blackmore, Analyst *95*, 439 (1970).
6 I. Sunshine, ed., Manual of Analytical Toxicology. Chemical Rubber Company, CRC Press, 1971.

Postural effects of neck muscle vibration in man

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Summary. Vibration of the dorsal neck muscles in man induces falling reactions, walking and 'marche en étoile', probably by muscle afferent activation. It can be used as a reproducible error signal in analyzing the interaction between neck muscle proprioception and vestibular as well as ocular motor systems. These interactions are important for posture and coordinated head-eye movements.

Muscle vibration in man induces postural and kinesthetic changes by muscle afferent activation[1]. Earlier studies have been restricted to the effects from vibrated arm, leg and trunk muscles. The neck muscle contains a high density of muscle spindles and is a powerful source for afferent input concerned in postural reflexes of the cat[2,3]. The present study was undertaken to investigate postural effects in man following neck muscle afferent activation induced by muscle vibration.

The vibrator used (Keydon) is an excentrically loaded electric motor set at 150 Hz. It was fixed to the dorsal neck muscles by a rubber strip around the forehead in normal persons. The vibrator was fixed either in the midline or more laterally on one of the splenius capitis muscles. The subjects tested, adults or children, were tested both blindfolded and with eyes open. The test was performed in the Romberg position, i.e. erect with feet together and the subjects were asked not to voluntarily overcome falling reactions.

After the onset of vibration there is a subjective experience of forward tilt as well as a real falling reaction of the whole body forward. The reaction differed somewhat in magnitude in different subjects, but has been observed in all 40 persons so far tested. The latency for the onset of the forward falling reaction is approximately 0.5 sec. If the vibration was kept on for a sufficient time, 3–5 sec, many of the persons tested were forced to make rather gross compensation movements, i.e. stepping forward, moving arms etc., to avoid a completed fall. If, on the other hand, vibration was stopped after a minor sway forward, the initial position was immediately regained without any 'over shoot' and the subjective experience of dysbalance was likewise quickly eliminated. Midline neck muscle vibration in small children (age 2–5 years) induced walking which looked quite natural and stopped when the vibrator was stopped.

The falling reaction was greatly reduced if the subjects kept the eyes open and it was also reduced by voluntary effort, or if successive trials were made within some min.

If the vibrator was fixed over the left splenius capitis muscle during a 'marche en étoile' test, deviation occurred anticlockwise and vice versa. The same effect was seen at a simple stepping test on the spot.

Tests were also performed on an inclined plane. Subjects were asked, blindfolded to turn around slowly during stepping. If neck muscle vibration to the midline was added the test became impossible to perform with precision. Actually the subjects stopped stepping and took a stable immobile position with knees bent.

Infiltration with a local anesthesia (xylocain) in the skin surrounding the vibrator had no effect on the falling reaction but infiltration in the splenius capitis muscles abolished the effect as long as the anesthesia was maintained. If the vibrator was placed over the occipital bone no falling reactions were obtained.

It is concluded that muscle receptors, probably within the splenius capitis muscles, are responsible for the effects. It is interesting to note that unilateral neck muscle vibration in man can induce a clinical sign (marche en étoile) sometimes found in patients with cerebellar diseases. Proprioceptive afferent input signalling position of head versus body can interact with postural effects evoked from the vestibular system. It is not known whether these neck muscle induced postural effects participate in this interaction. Neck muscle proprioception is a vital part of coordinated head-eye movements. Also in this quite different task for the proprioceptors of the neck muscles the vibrator could be a useful tool in clinical studies, e.g. at oscillopsia. Further studies are in progress.

1 G. Eklund and K.E. Hagbarth, Exp. Neurol. *16*, 80 (1966).
2 V.C. Abrahams and S. Falchetto, J. Physiol. *203*, 435 (1969).
3 R. Magnus, Körperstellung. Springer, Berlin 1927.