Arh. hig. rada toksikol., **30** *(1979) suppl. pp. 719–726.*

STUDY OF SOME BIOCHEMICAL CHANGES IN WORKERS EXPOSED TO NOISE IN A TEXTILE INDUSTRY

M.H. NOWEIR, H.M. ABDEL-KADER, R.M. EL-GAZZAR, M. MOSELHI and S. GHORAB

High Institute of Public Health, University of Alexandria, Alexandria, Egypt

ABSTRACT

Biochemical changes including blood glucose and urea, serum sodium and potassium and urinary excretion of 17-ketosteroids and total catecholamines were studied in 183 textile workers exposed to average noise levels of 89, 93.5 or 96.5 dB for different durations, as well as in a control group of 51 workers.

The results of the study indicated that blood glucose, serum sodium and potassium did not significantly change in any of the exposed groups from the control subjects. Blood urea showed significant increase in the groups exposed to 93.9 and 96.5 dB, while their urinary excretions of 17-ketosteroids were significantly lower than that of the controls. The levels of the total urinary catecholamines of all exposed groups were significantly higher than the controls.

These findings substantiate the belief that noise, as stressor could be a predisposing factor in some diseases such as cardiovascular, neurological and hormonal disorders. It might be, also, concluded that the assessment of blood urea and/or urinary total catecholamines in the groups exposed to noise may be used for screening workers who abnormally respond to such stress.

Apart from hearing loss, noise can adversely affect man in various ways. Recent reports suggest a connection between noise and disturbance of various physiological functions including cardiovascular, glandular, respiratory and neurological changes, all of which are suggestive of general stress reaction[6,13,16]. Numerous authors claim that noise provokes a physiological stress reaction through reflex stimulation of the auditory nerve and of the hypothalamus[5].

It is well known that a number of stressors can elicit an increased release of corticoids due to the stimulation of the sympathetic–adrenal medullary system[14]. These hormones can induce a variety of biochemical changes which depict the organism's attempt to cope with environmental stress[3,21]. For example, the exposure of animals to intense noise, particularly to high frequency noise for protracted periods led to a marked depletion of adrenal constituents and to several pathological changes in different body systems[1]. Such changes have been considered to indicate that the physiological tolerance or ability of the animal to adapt to a stressful situation has been exceeded. It is plausible to expect similar findings in man; however, neither the levels nor the exposure conditions that exceed the physiological tolerance to noise are known[7].

The best evidence that noise may act as physiological stress comes from direct analysis of changes in the adrenal cortex and evidence of the secretion of corticosteroids in the blood and urine. Some authors observed substantial elevations of free plasma 17-hydroxycorticosteroids and urinary 17-ketosteroids (17-KS) in men exposed to sound in the range from 65 to 93 dB and it has been claimed that the measurement of urinary 17-KS presents a meaningful index of the physiological reaction to noise[21]. Furthermore, it has been reported that, in general, changes in the synthesis and degradation of catecholamines are produced under the influence of long-lasting acoustic stimuli[17].

The present study was therefore conducted to uncover evidence supporting the association between occupational noise exposure and changes in urinary excretion of 17-KS and total catecholamines and changes in blood glucose and urea, and serum sodium and potassium in workers exposed to different levels of noise. This is in an endeavour to use some of these parameters for the early detection of abnormal response to noise.

SUBJECTS AND METHODS

A group of 183 male workers was randomly selected from the total population of workers in three different textile operations, viz: weaving preparation ($n = 25$, 13.7%), spinning ($n = 60$, 32.8%) and weaving ($n = 98$, 53.5%), in a textile plant located in Kafr El-Dawar, close to Alexandria. The average noise levels in the different departments were determined to be 89, 93 and 96 dB respectively[19]. A control group of 50 male subjects of matched age and of similar socio-economic status as that of the selected workers were similarly chosen from the auxiliary workers in the same plant who had jobs known to be away from noise exposure.

Blood samples were collected from each exposed worker, as well as from the control subjects after four hours of noise exposure in the shift. The samples were taken by vein puncture in vacutainer tubes. Each sample was divided to get a portion as total blood for the determination of blood glucose and blood urea. The other portion of the sample was allowed to clot and the serum was separated (by centrifugation) for the determination of sodium and potassium.

Spot urine samples were collected from each of the examined subjects (exposed and control) for the determination of 17-KS and total catecholamines.

The blood glucose and urea were determined as described by Varley[24]. The serum sodium and potassium were determined by means of the Atomic Absorption Spectrophotometer as described in the PYE Unicam Manual[20]. The urinary 17-KS were determined with the Sigma Kit[22]. Urinary total catecholamines were absorbed on amberlite resin (IRC-50), eluted and determined by the modified method of Weil-Melherbe and Bone[24]. Both urinary 17-KS and total catecholamines were expressed on the basis of the urinary creatinine content as determined by Folin method[24].

RESULTS

Noise exposure

The noise levels to which the examined workers were continuously exposed during the work shifts are summarized in Table 1. It is clear that the workers in the weaving were exposed to the highest level of noise followed by those in spinning and the lowest level in the weaving preparation. The level of the background noise in the locations from which the control subjects were selected ranged from 69 to 74 dB.

TABLE 1
Noise levels in the different textile operations.

Occupation	Noise levels (dB)	
	Range	Average
Control subjects	69.0 – 74.5	71.5
Weaving preparation	81.0 – 81.5	81.3
Spinning	92.0 – 95.0	93.5
Weaving	96.0 – 97.0	96.5

Variation of blood glucose and urea and serum sodium and potassium with the level of noise exposure

The levels of blood glucose and urea in the workers exposed to different levels of noise and in the control subjects are presented in Table 2. The average age of the examined groups ranged from 35.0 to 39.8 years and no significant difference was observed in their age. The duration of exposure of the different groups was not significantly different, except for the workers in the weaving preparation whose average exposure was 23.0 years while for the other three groups it ranged from 13.8 to 16.4 years.

The levels of blood glucose did not show any significant difference between the exposed and control subjects. However, a slight decrease of the mean blood glucose in the examined groups was observed as a result of the increase in the level of noise exposure. The levels of blood urea among the different workers exposed to noise showed a significant increase ($p < 0.01$) with the higher levels of noise (spinning 93.5 and weaving 96.5 dB) as compared to that of the controls.

Serum sodium and potassium did not show any significant change in any of the noise exposed groups from the control values.

Variation of urinary 17-ketosteroids and total catecholamines with levels of noise exposure

The levels of the urinary 17-KS and total catecholamines of the examined workers based on the urinary creatinine content are presented in Table 2. The mean levels of urinary 17-KS for the groups exposed to high levels of noise (i.e.

TABLE 2

Levels of blood glucose and urea and urinary 17-ketosteroids and total catecholamines in workers exposed to different levels of noise (mean ± S.D.).

Occupation	Average noise level (dB)	Number examined	Age (years)	Duration of exposure (years)	Blood glucose (mg/100 ml)	Blood urea (mg/100 ml)	17-KS (mg/g creatinine)	Total catecholamines (μg/g creatinine)
Control	71.5	51	35.8 ± 12.9	13.8 ± 3.6	93.7 ± 16.3	24.6 ± 5.4	10.5 ± 1.6	48.9 ± 18.5
Weaving preparation	81.3	25	39.8 ± 5.9	23.0 ± 4.3	91.7 ± 14.9	27.1 ± 5.2	10.1 ± 1.6	61.8 ± 10.5**
Spinning	93.5	60	35.0 ± 14.2	14.6 ± 0.3	89.7 ± 12.5	30.4 ± 8.4**	9.7 ± 2.0*	68.8 ± 16.7**
Weaving	96.5	98	38.0 ± 11.7	16.4 ± 10.4	89.9 ± 13.0	30.9 ± 9.7**	9.9 ± 1.9*	73.5 ± 14.2**

*$p < 0.05$; ** $p < 0.01$

spinners 93.5 dB and weavers 96.5 dB) were significantly lower ($p < 0.05$) than those of the controls, while the mean level in workers exposed to relatively lower noise levels (i.e. weaving preparation, 81.3 dB) was not significantly different from that of the controls.

On the other hand, the mean levels of total catecholamines of all the exposed workers were significantly higher ($p < 0.05 - 0.01$) than those of the control subjects. The increase in the urinary catecholamines showed intermediate correlation with noise exposure ($r = 0.52$).

Variation of measured parameters with the duration of exposure

The exposed workers were distributed according to the duration of exposure to noise and the mean levels of the measured parameters were compared with those of the controls in Table 3. The urinary catecholamines were significantly higher in all the examined subgroups exposed to noise for different durations than in the controls. The decrease in the levels of urinary 17-KS did not show any specific pattern with duration of exposure. The increase in the blood urea, for the workers exposed to high noise (e.g. spinners and weavers), was high in the subgroups exposed for less than 10 years followed by a relative reduction in the subgroups exposed for periods ranging from 10 to 20 years and an increase again in the subgroups exposed for durations longer than 20 years.

TABLE 3
Variation of some of the measured parameters with the duration of exposure to different levels of noise (mean ± S.D.).

Operation (average noise)	Duration of exposure (years)	Number of workers	Age (years)	Blood and urine parameters		
				Blood urea (mg/100ml)	Urinary 17-KS (mg/g creat.)	Urinary total catecholamine (µg/g creat.)
Control (71.5 dB)	–	51	35.8 ± 12.9	24.6 ± 5.4	10.5 ± 1.6	48.9 ± 16.5
Weaving preparation (81.3 dB)	<10	–	–	–	–	–
	10–	8	34.0 ± 7.5	29.4 ± 3.3*	10.0 ± 1.5	65.8 ± 8.3**
	20+	17	42.4 ± 4.3	26.0 ± 5.6	10.0 ± 1.6	59.9 ± 11.1*
Spinning (93.5 dB)	<10	28	32.8 ± 5.3	30.3 ± 7.3**	9.5 ± 2.3*	68.6 ± 18.3**
	10–	7	34.1 ± 4.5	25.3 ± 3.7	9.8 ± 1.5	76.4 ± 15.7**
	20+	25	49.1 ± 5.0	32.0 ± 9.6**	9.8 ± 1.9	66.2 ± 15.7**
Weaving (96.5 dB)	<10	32	21.7 ± 4.2	30.9 ± 9.4**	10.6 ± 1.6	70.6 ± 17.5**
	10–	15	35.8 ± 5.1	27.8 ± 10.2	10.6 ± 1.6	78.2 ± 12.0**
	20+	51	46.6 ± 5.0	32.7 ± 10.1**	9.1 ± 1.9**	73.8 ± 13.6**

*$p < 0.05$; **$p < 0.01$

DISCUSSION

The data presented in this study clearly indicated that exposure to continuous noise at levels above 80dB brings about changes in some biochemical parameters including blood urea and urinary excretion of 17-KS and total catecholamines.

However, the slight decrease of blood glucose in workers exposed to relatively high noise was also observed by other authors. For example, Hasan[12] reported a decreased blood glucose and glycogen content in rabbits exposed to noise and vibration, while Simpson and co-workers[23] proved that the effects of noise stress on skilled performance could be modified by glucose preloading. Besides, Ashbel[4] presented evidence of a relationship between the levels of blood glucose and noise and recommended a high carbohydrate diet for workers exposed to high frequency noise.

The increase of blood urea observed in workers exposed to noise in our study, although it was always within the normal universal range of blood urea (20 – 40 mg/100 ml) was significant specially in workers exposed to relatively high noise levels (e.g. spinners and weavers). These findings are in agreement with the results of other authors. Wesson[25] demonstrated a relationship between the psychological or physical stress and the excretion of urea, while Anthony and Ackerman[1] demonstrated that guinea-pigs exposed to prolonged noise showed tissue damage to kidney. Recently such changes have been atributed to increased noradrenaline excretion which augments the permeability of the glomerules membrane to protein and, at the same time, might affect the tubular re--absorption of protein[8]. However, the phenomena observed among the examined workers regarding the variation of the blood urea with duration of exposure need further follow-up investigations.

Noise, as a general stressor, has been known to stimulate the activity of the sympathetic nervous system and it has been anticipated that exposure to noise may lead to excessive excretion of the hormones of the sympathetic adrenal medullary system, adrenaline and noradrenaline[11]. However, the effect of noise on the endocrine system has been a subject of contradiction among various investigators. While some investigators reported increased urinary excretion of endocrine metabolites after stressful reactions, others denied such effects[8,10]. The data presented in this study show that the urinary excretion of catecholamines increased significantly and steadily ($p < 0.01$, $r = 0.52$) with increased levels of noise exposure. This effect might be attributed to increase in the secretion of adrenaline and/or noradrenaline. Both of these hormones were reported to be elevated after physical exercise, mental work or emotional stress[10]. Moreover, changes in catecholamines were reported even at a quite low level of noise exposure[9]. However, the excretion of both adrenaline and noradrenaline has been reported to depend also on the psychological status of the studied subjects as well as on their physical fitness and mental state[8].

Similar to catecholamine excretion, the reports on the effect of stress on urinary 17-KS excretion are contradictory. While Arguelles and co-workers[2] demonstrated increased excretion of urinary 17-KS in men exposed to noise, our data show that the urinary excretion of 17-KS decreased in workers exposed to noise in different textile operations.

It may be assumed that such contradiction in the results which concern endocrine metabolites is due to a difference in the conditions of the stresses to which the subjects were exposed in different studies. The urinary excretion of such metabolites is a combined action of many factors of the neural and endocrine regularity systems which play a major role in the homeostatis[8]. It is also known that hormones do not exert individual effects on different organ systems and biochemical processes in the body, but represent only a part of such effects[8,18]. Moreover, the measurements of such metabolites could vary considerably according to the time of the stressful action, the subject's physical fitness and environmental factors[15].

It may be concluded that the present findings substantiate the belief that noise, as stressor, could be a predisposing factor for the development of cardiovascular, neurological and hormonal disorders. However, further studies are recommended to investigate the changes in the system in comparison to the changes in the presently studied parameters. Meanwhile, the assessment of urinary total catecholamines and/or blood urea in workers exposed to noise may be used for screening the subjects who abnormally respond to such stress.

REFERENCES

1. *Anthony, A. and Ackerman, E.* Stress Effects of Noise (WADC Technical Report 58-622), Wright-Patterson AFB, Ohio, 1959.
2. *Arguelles, A.G., Martinez, M.A., Pucciarelli, E. and Disisto, M.V.* Endocrine and Metabolic Effects of Noise in Normal, Hypertensive and Psychotic Subjects. In: Physiological Effects of Noise, Welsh, B.L. and Welch A.S., ed. Plenum Press, N.Y., London 1970, pp. 43–56.
3. *Arguelles, A.E., Ibeas, D., Pomes Ottone, J. and Chekherdemian, M.* Pituitary-adrenal stimulation by sound of different frequencies. J. Clin. Endocrinol., **22** (1962) 846–852.
4. *Ashbel, Z.Z.* The effects of ultra sound and high frequency noise upon the blood sugar level. Gig. Tr. Prof. Zabol., **9** (1965) 29–33. [Abstracted in Bulletin Hygiene, **40** (1965) p. 587].
5. *Carlestam, G., Karlsson, C.G. and Levi, L.* Stress and Disease in Response to Exposure to Noise. Ward, W.D. ed. A Review Proceedings of the International Congress on Noise as a Public Health Problem, Dubrovnik, Yugoslavia, 1973, U.S. Environmental Protection Agency, Washington, D.C., 1973, pp. 479–486.
6. *Cohen, A.* Noise effects on health, productivity and well-being. Trans. N.Y. Acad Sci., **30** (1968) 910–918.
7. *Cohen, A.* Extra-auditory effects of noise as a health hazard. Am. Ind. Hyg. Assoc., **31** (1970) 277–286.
8. *Dukes-Dobos, F.N.* Fatigue from the point of view of urinary metabolites. Ergonomics, **14** (1971) 31–40.
9. *Elmadjian, R., Lamson, E.T. and Neri, R.* Excretion of adrenaline and noradrenaline in human subjects. J. Clin. Endocrinol. Metab., **16** (1956) 222–234.
10. *Euler, V.* Adrenaline and Noradrenaline in Various Kinds of Stress. In: Symposium on Stress, Army Medical Services Graduate School of Walter Read Army Medical Centre, Washington, D.C., 1953.
11. *Hale, H.B., Anderson, C.A. and Williams, E.W.* Endocrine-metabolic effects of unusually long or frequent flying missions in C-130 E or C-135 B aircraft. Aerosp. Med., **39** (1968) 561–570.

12. *Hasan, J.* Biochemical aspects of low frequency vibration. Work Environ. Health, **6** (1970) 19–25.

13. *Jansen, G.* Effects of Noise on the Physiological State. American Speech and Hearing Association Report No. 4, Proceedings of National Conference on Noise as Public Health Hazard, Washington 1969, pp. 89–98.

14. *Levi, L. (ed.).* Emotional Stress, Physiological and Psychological Reactions: Medical, Industrial and Military Implications, American Elsevier Publishing Company, New York, 1967.

15. *Lidberg, L., Levander, S.E., Schalling, D. and Lidberg, Y.* Excretion of Adrenaline and Noradrenaline as Related to Real Life Stress and Psyhopathy. Report from the Laboratory for Clinical Stress Research, Stockholm, 1967, pp. 1–.15.

16. *Margolis, B.L., Kroes, W.H. and Qinn, R.P.* Job stress: an unlisted occupational hazard. J. Occup. Med., **16** (1974) 659–661.

17 *Markiewicz, L.* Some Data on the Influence of Noise on Neurohumoral Substances in Tissues and Body Fluids. Ward, W.D., ed. Proceedings of the International Congress on Noise as a Public Health Problem, Dubrovnik, Yugoslavia, 1973, U.S. Environmental Protection Agency, Washington, D.C. 1973, pp. 473–478.

18. *Mason, J.W.* Organization of psychoendocrine mechanisms. The scope of psychoendocrine research. Psychosom. Med., **30** (1968) 565–575.

19. *Noweir, M.H.* Effects of Noise Exposure on Productivity, Penalties, Absenteeism and Accidents of Textile Workers. Part I of the Final Report of the Research Agreement. "Exposure to Noise in the Cotton and Flax Textile Industry", High Institute of Public Health, University of Alexandria, 1977.

20. *Pye Unicam Method Sheets.* Sodium and Potassium in Serum. Atomic Absorption Spectrophotometry Methods. Unicam, Instrument Ltd., Cambridge, England.

21. *Sackler, A.M., Weltman, M.B. and Justshuk, P.* Endocrine changes due to auditory stress. Acta Endocrinol., **31** (1959) 405–418.

22. *Sigma Technical Bulletin. No. 17.* Determination of 17-ketosteroids in Urine.

23. *Simpson, G.C., Cox, T. and Rothschild, D.R.* The effects of noise stress on blood glucose level and skilled performance. Ergonomics, **17** (1974) 481–487.

24. *Varley, H.* Practical Clinical Biochemistry, 4th ed. William Heineman, Medical Board Ltd., London, England, 1967, pp. 19, 86 and 684.

25. *Wesson, L.G.* A theoretical analysis of urea excretion by mammalian kidney. Am. J. Physiol., **179** (1954) 364–371.