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CLINICAL AND HYGIENIC ASPECTS OF EXPOSURE TO ELECTROMAGNETIC FIELDS

(A Review of the Soviet and Eastern European Literature)[1]

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INTRODUCTION

It has long been apparent that electromagnetic fields impose a health hazard, especially at field intensities greater than approximately 15 mW/cm², which cause thermal (heating) responses in the organism. Only quite recently it is suspected, from the Soviet and East European literature, that these fields might also elicit certain functional or so-called "specific" responses, especially in the nervous system, at field intensities less than 10–15 mW/cm², which do not cause heating.

Prior to 1964, no comprehensive effort had been attempted in this country to review the world (especially the Soviet and East European) literature on the general biological effects of microwaves. Soviet literature was in most cases scattered, quite difficult to locate, and consequently had never come to the attention of the U.S. scientific community. When in 1964, one of the first reviews on this subject was attempted by the writer, then affiliated with the Library of Congress, it was speculated by some authorities on the subject that an extremely low yield of literature would result from the attempt. It was therefore quite surprising that a search of the Soviet and Eastern European literature on the biological effects of microwaves revealed a large and virtually unexploited body of information which had never come to the attention of the U.S. scientific community. The first review (1) contained 132 references to Soviet and East European work on this subject. Subsequent reviews by the author (2–4) and a number of others (5–9) revealed that some of the most active research in the world was being conducted in the Soviet Union and some of the Eastern European countries.

It is the purpose of this paper to review Soviet and Eastern European studies of the effects of radiofrequency fields on the human organism. An attempt will be made to summarize the more noteworthy findings of some of the literally hundreds of published works devoted to this subject and to underscore the need for a more critical and systematic treatment of this subject. This review will concentrate nearly exclusively on human clinical studies and occupational hygiene surveys and will not consider the more theoretical or experimental aspects of the biological effects of microwaves.

BACKGROUND

As early as 1933, certain Soviet scientists had already recognized that electromagnetic fields affected the human nervous system. In 1937, Turlygin (10) published one of the first comprehensive Soviet accounts of the effects of centimeter waves on the human central nervous system. He found that CNS excitability was increased by 100% of the control level when a crude spark oscillator in the vicinity of the head of a subject was switched on. In a lengthy review article, Livshits (11) cited no fewer than 28 Soviet publications on the general subject of clinical and biological microwave effects which had been published by the end of the 1930's.

During the 1940's and early 1950's, there was an understandable lull in research on this subject due to World War II. By the middle and late 1950's, there appeared a veritable deluge of Soviet literature dealing, in the main, with the clinical and hygienic aspects of microwave exposure which has continued unabated to this day. By the early 1960's, the Eastern European countries of Czechoslovakia and Poland had also become extremely active in the area of microwave exposure effects. In a cursory

[1] The views expressed by the author do not necessarily represent those of the U.S. Navy.

search of the Soviet and Eastern European literature on this subject alone, a total of about 100 publications authored by 75 researchers was found and this figure is probably a conservative reflection of the available works which are estimated to be several hundred.

In an attempt to summarize the prolific Soviet and Eastern European work on clinical and hygienic aspects of exposure to microwaves, it became apparent that a number of human systems and functions had been documented to be affected by this factor (Table 1). By far the most frequently and repeatedly reported human responses to microwaves involve the central nervous system. These responses have been noted for a wide range of frequencies (~30–300,000 MHz) at both thermogenic (>10 mW/cm²) and nonthermogenic (microwatts to milliwatts/cm²) intensities.

An often disappointing facet of the Soviet and East European literature on the subject of clinical manifestations of microwave exposure is the lack of pertinent data on the circumstances of irradiation; frequency, effective area of irradiation, orientation of the body with respect to the source, waveform (continuous or pulsed, modulation factors) exposure schedule and duration, natural shielding factors, and a whole plethora of important environmental factors (heat, humidity, light, etc.) In addition, the physiological and psychological status of human subjects such as health, previous or concomitant medication, and mental status is also more often than not omitted. These variables, both individually and combined, affect the human response to microwave radiation. Despite these omissions, however, the reviewer cannot help but be impressed both by the consistency of the findings and the large size of Soviet and East European clinical and hygienic surveys which have involved literally thousands of people over the past 20 or more years.

CLINICAL MANIFESTATIONS OF EXPOSURE TO RADIOFREQUENCY FIELDS

General Clinical Syndromes

Many Soviet clinical workers have attempted to categorize the chronological stages of human responses to microwaves. Panov et al. (12) proposed three categories or stages of responses to microwaves (Table 2). These were listed as the asthenic syndrome, characterized by fatigue, depression, and a number of other changes. This first stage is not marked by severe episodes such as fainting or dramatic changes in pulse or blood pressure and the subject responds to outpatient treatment. The second category is called the "syndrome of autonomic and vascular dystonia". The essential feature of this stage is pulse lability (brady- and tachycardia), blood pressure lability (hypo- or hypertension), EKG changes, and general neurocirculatory asthenia. Severe episodes such as fainting spells may occur and the subject requires hospitalization of unspecified nature or duration. The third stage is referred to as the diencephalic syndrome in which visceral dysfunctions and crises are observed. Typical episodes during this stage are listed as "apathic ambulic" disorders, hypersomnia, hypokinesis, hypothalamo-pituitary-suprarenal weakness, and inhibition of sexual and digestive reflexes. Panov claims that these changes are not always reversible and that subjects require hospitalization. It should be noted that Panov did not specify the nature or duration of outpatient or hospital treatment, nor did he relate these symptoms to specific irradiation parameters.

TABLE 1

Effects of electromagnetic radiation on the human organism

I. Central Nervous System
II. Autonomic Nervous System
III. Neurohumoral Systems
IV. Endocrine Glands and Functions
V. Eye and Ocular Functions
VI. Blood and Hematopoietic Systems
VII. Miscellaneous Organs

General Subjective Complaints (Indirect Effects on the CNS)

A large number of East European and especially Soviet clinical and hygienic workers (13–22) have consistently and repeatedly documented an astonishing number of subjective complaints which are usually referred to as evidence of the direct or indirect effect of microwaves on the central nervous system (Table 3). These responses have been reported for a wide range of wavelengths (30–300,000 MHz) and field intensities (microwatts to several milliwatts/cm²). Unfortunately, it is often difficult to attach any significance to Soviet clinical findings in the absence of pertinent data on exposures and on patient backgrounds. Typical, for instance, was a survey conducted by Sadchikova (21) in which three groups of occupational personnel (technicians, assemblers, and maintenance workers around centi-

TABLE 2

Soviet classification of general clinical syndromes of exposure to electromagnetic radiation EMF's

A. The Asthenic Syndrome (reversible; outpatient treatment)
   1. fatigability and emotional changes
   2. acrocyanosis
   3. increased perspiration of extremities
   4. increased pilomotor reflex
   5. dermographism
   6. pulse lability
   7. blood pressure lability
B. Autonomic Cystonia (reversible; hospitalization)
   1. hyper- or hypotension
   2. bradycardia and tachycardia
   3. changes in EKG signs
   4. fainting spells
C. Diencephalic Syndrome (usually reversible; hospitalization)
   1. insomnia
   2. adynamia
   3. hypothalamo-pituitary-suprarenal inhibition
   4. inhibition of sexual function and digestive reflexes

meter wave generators) were exposed to: (1) periodic intense radiation (3–4 mW/cm²); (2) moderate radiation (tenths of mW/cm²); and (3) weak radiation (hundredths-tenths of mW/cm²). As can be seen in Table 4, the group exposed to the weakest radiation was shown to display the highest incidence of complaints. This finding and lack of pertinent exposure data such as duration and affected body area make these data difficult to accept on face value. On the other hand, Edelwejn (14) has conducted interesting and comprehensive neurological examinations and interviews of Polish personnel exposed for up to six hours/day to microwave field intensities of 10 microwatts to several milliwatts/cm². He found that many of the subjective complaints listed in Table 3 (headaches, dizzy spells, fatigue, perspiration, etc.) depended upon the length of employment and degree of exposure. Only subjects exposed to high (mW/cm²) intensities exhibited EEG changes. Edelwejn was of the opinion that there is a dramatic response to microwave exposure occurring during the first three years which are accompanied by neurotic symptoms. This three year period is followed by a phase of gradual adaptation. The reappearance of neurologic symptoms occurs after a long period (many years) of exposure to microwaves, even after adaptation has occurred.

Osipov (1965) (20) in a review of neurologic responses to microwave exposure concluded that most subjective symptoms were reversible and that pathological damage to neural structures was insignificant. Only rarely were microwaves found to cause hallucinations, syncope, adynamia and other manifestations of the so-called "diencephalic" syndrome.

Soviet workers have also documented subjective complaints identical to those in Table 3 as a result of exposure to electric and magnetic fields. Vyalov et al. (23) reported characteristic microwave symptoms such as headache, fatigue etc., in workers exposed to 150–1500 oersted magnetic fields. Asanova (24) reported analagous findings for workers exposed to 115–125 microampere fields around hydroelectric stations.

Functional Changes in the CNS

Many Soviet and Eastern European workers have attempted to identify specific CNS functional responses to microwave exposure. Most Soviet workers are of the opinion that the CNS is the most sensitive of all systems to the effects of microwaves, both at thermogenic and nonthermogenic field intensities. Based primarily upon experimental research, Presman (9) is of the opinion that the hypothalamus is the most sensitive CNS structure to microwave effects which would explain, in his view, the high incidence of blood and humoral changes noted in human subjects exposed to this factor.

Changes in human CNS function have been evaluated on the basis of EEG surveys, reflex tests, and general neurological examinations (Table 5). These changes are reported for a wide range of frequencies and field intensities (thermal and nonthermal). However, functional CNS responses appear to be de-

TABLE 3

General subjective complaints resulting from exposure to electromagnetic radiation

1. Pain in head and eyes
2. Lacrimation
3. Weakness, weariness and dizziness
4. Depression, antisocial tendencies, general irritability
5. Hypochondria, sense of fear, and general tension
6. Impairment of memory and general mental function
7. Adynamia and inability to make decisions
8. Inhibition of sex life (male)
9. Scalp sensations and loss of hair
10. Chest pain and heart palpitation
11. Dyspepsia, epigastric pain, and loss of appetite
12. Trembling of eyelids, tongue, and fingers
13. Asthma
14. Brittle fingernails
15. Sensitivity of mechanical stimulation and dermographism

TABLE 4

Changes in the nervous system as a result of exposure to microwaves

		Changes observed (in % of subjects studied)							
Group	No. examined	Headache	Increased fatigue	Increased irritability	Sleepiness	Delayed der-morgraphism	Slowed orthostatic reflex	Wrist hyperdrosis	Thyroid hypertrophy
1	184	12	20	8	2	16	19	6	15
2	129	39	31	12	14	7	21	37	—
3	78	36	31	15	19	14	11	26	52
Control	100	8	10	8	2	—	—	4	14

pendent upon wavelength; direct effects on the brain were reported by Gordon (1964) (25) and Presman (9) to intensify with increase in wavelength. However, when reactions are due to a combination of peripheral and direct stimulation, it is impossible to correlate response with wavelength.

A number of workers have reported changes in EEG patterns as a result of exposure to microwaves. Klimkova-Deutschova (26), a Czechoslovakian researcher, reported that both clinical and EEG findings suggested a predominance of an inhibition process. EEG's showed a predominance of sleep rhythms. In this connection, the interesting (if rather curious) work of Ivanov-Muromskiy (27), a Soviet expert on electrosleep and electroanesthesia deserves comment. His research on human subjects suggested that pulsed (10–1000 Hz) UHF fields of nonthermal intensity directed from bitemporal electrodes a few inches from the subject's head could induce inhibition similar to that produced by pulsed electrical currents (electrosleep). Unfortunately, this research was not described in detail by Ivanov-Muromskiy.

TABLE 5

Functional CNS changes resulting from exposure to electromagnetic radiation

1. Changes in EEG patterns
   a. "asthenic" signs
   b. predominance of inhibition process
   c. increased incidence of slow, high amplitude waves
   d. decreased incidence of alpha rhythms and waves
   e. predominance of "sleep" rhythms
2. Perceptual changes
   a. hallucinations (visual)
   b. decrease in ocular blind spot area
   c. shortening of optic chronaxie and reduction of rheobase
   d. auditory sensitivity changes
   e. decreased olfactory sensitivity
   f. increased olfactory activity
   g. parapsychologic phenomena
3. Alternating arousal and drowsiness
4. Stimulation of motor functions
5. Depression of mental functions
6. Involuntary motor reactions

Drogichina (13) reported that CNS damage is characterized by the "asthenic syndrome" which can be detected from EEG and neurological findings. Presman (9), in reviewing Soviet, Czechoslovakian, and Polish work, reports that the EEG's of subjects exposed to weak (nonthermal) microwave field intensities show an increased incidence of slow, high amplitude waves. In Poland, Edelwejn and Baranski (14) reported a decreased incidence of alpha rhythms and a decreased percentage of alpha waves in subjects exposed to "high" (mW/cm^2) intensities of microwave fields. All subjects examined in this study over-reacted to the administration of cardiozol, a respiratory and cardiac stimulant. In general, because of the rather primitive state-of-the-art of EEG analysis, these findings should be viewed with extreme caution.

Perceptual changes as a result of exposure to microwaves have also been frequently reported. Livshits (28) reported that "high intensity" microwaves had been found by Soviet workers to cause hallucinations. He also reported that high frequency, high intensity fields had been demonstrated to cause involuntary motor reactions in one healthy individual. Matuzov (29) noted visual perception changes after a 10 minute exposure to 10 cm microwaves of nonthermal (1.1 mW/cm^2) intensity. He found a considerable decrease in blind spot area,

TABLE 6

Autonomic and cardiovascular effects of electromagnetic radiation

1. Changes in cardiac function (EKG)
   a. decreased spike amplitude
   b. lengthened QRS interval
   c. slowed auricular and ventricular conductivity
2. Bradycardia and tachycardia
3. Hyper- and hypotension
4. Increased precapillary resistance
5. Increased vascular elasticity

shortening of optic chronaxie, and reduction of rheobase in two subjects. These effects were judged to be nonthermal (specific) and were found to be reversible. Sheyvekhman (30) noted changes in auditory sensitivity (5–10 dB) in response to 6 meter waves pulse modulated at 300, 1000, or 4000 Hz applied for five minutes to the heads of human subjects. He did not clarify whether sensitivity was increased or decreased. Lobanova and Gordon (31) noted a decrease in olfactory sensitivity after exposure to microwaves and suggested that this response might be a good index for identifying harmful microwave effects. These authors also found an increase in olfactory excitability (decreased threshold) after a single dose of caffeine. This was suggested as evidence of functional olfactory changes caused by microwaves.

In the realm of parapsychology, it is interesting to note that leading Soviet researchers who strongly believe in the nonthermal CNS effects of microwaves are involved in the electromagnetic (centimeter wave) theory of extrasensory perception (3). This work, initiated in 1966, is being conducted for a special Bioinformation Section of the Scientific and Technical Society of Radiotechnology in Moscow. The results of Soviet ESP research have thus far been interesting but statistically inconclusive.

Both the stimulatory and inhibitory effects of microwaves on CNS function have been frequently documented by Soviet workers. Subbota (32) reported alternating arousal and drowsiness in response to microwaves in working with dogs. As mentioned earlier, the Soviet electrosleep expert, Ivanov-Muromskiy (27) concluded from his studies of human subjects that pulsed UHF fields could be used as a form of contactless electrosleep which he calls "radiosleep". Depression of mental function, inability to concentrate, and general sluggishness is frequently documented by Soviet and Eastern European researchers as a subjective response to microwave exposure.

Autonomic and Cardiovascular Responses

Reports of human autonomic and cardiovascular responses to microwaves are nearly as numerous as those documenting CNS responses to this factor (Table 6). Responses are noted for a wide range of frequencies at thermal and nonthermal field intensities and during acute and chronic exposure. Decreased EKG spike amplitudes have been noted by Drogichina (33) in subjects working around radiofrequency fields. Sadchikova (34) reported on various cardiovascular shifts in workers exposed to different field intensities (Table 7). Figar (15) and Smurova (35) have noted decreased coronary conductivity, sinusoidal arrythmia, brady- and tachycardia, and oscillating hypo- and hypertension. Monayenkova et al. (36) studied minute blood volume, peripheral resistance, average arterial pressure, and smooth muscle tonus using a mechanocardiograph. She found that a tendency toward hypertension, increased elasticity of myogenous vessels, increased precapillary resistance, sinus bradycardia, and changes in intracardiac conductivity were more often noted in exposed than in unexposed subjects. All of these changes were found to be reversible with one or two questionable exceptions.

There is some evidence that certain enzymes implicated in CNS function might be affected by exposure to microwaves (Table 8). Revuts'kyy et al. (37) found a change in the specific cholinesterase activity of erythrocytes in human whole blood with 13.56 and 23.75 MHz microwaves. The 13.56 MHz radiation was found to decrease blood histamine content while not altering cholinesterase activity. The 23.75 MHz radiation did not change blood histamine content but increased cholinesterase activity. Bartonicek et al. (38) surveyed the blood biochemistry of workers exposed to centimeter waves. Of a total of 27 blood sugar curves, 7 were flat, 7 were prediabetic, and four indicated slight glycosuria. The distribution of pyruvic and lactic acid and creatinine are shown in Table 9. Lactic acid was found to be decreased 2.5 times more than it was found to be increased. Roughly 75% of the subjects exposed to microwaves and examined by Bartonicek were reported to have prediabetic blood sugar curves. These metabolic shifts were attributed to autonomic dysregulation, possibly indicative to diencephalic lesions resulting from early exposure to centimeter

TABLE 7

Cardiovascular changes in subjects exposed to electromagnetic radiation (Sadchikova, 1964)

	EMF parameters	Exposure/control ratio		
Range	Field intensity	hypertonia	bradycardia	increase of QRS interval (up to 0.1 sec)
SHF	1-several mW/cm²	1.85	24.0	11.5
	1 mW/cm²	2.0	16.0	12.5
UHF	nonthermal	1.2	8.0	21.0
LF	tens to hundreds V/M	9.21	12.0	—
	hundreds to 1000 V/M	1.2	5.0	—
Percent incidence in controls		14%	3%	2%

waves. Gel'fon and Sadchikova (39) noted increased blood globulins in 50% of a group exposed to microwaves which indicated a shift in the albuminglobulin coefficient. Haski (40) noted slight changes in the levels of blood sugar, cholesterol, and lipids of healthy subjects exposed to microwaves. However, there was a pronounced decrease in all three categories when diabetics were exposed.

Hematopoietic and Biochemical Responses

Numerous human hematopoietic changes have been reported to result from exposure to microwave fields (Table 10). The severity of these changes range from minimal to significant. Sokolov (41) noted reticulocytosis in radar workers. Baranski (42) observed that a small drop in erythrocytes occurs in all people exposed to microwaves and that the phenomenon is related to the duration and severity of exposure. About 50% of the subjects examined by Baranski showed a moderate decrease in platelet count. Lysina (43) noted basophilic granularity of erythrocytes and was of the opinion that this index should be taken as an initial sign of microwave effects on the human organism. Presman et al. (44) found that the osmotic resistance of erythrocytes was negatively affected by microwaves. Smurova (22) and others found that the shape and volume of erythrocytes changes as a result of exposure to microwave fields. Prolonged exposure was occasionally noted to result in hemolytic processes. An increase in the RNA level of lymphocytes was also noted by Smurova in workers chronically exposed to microwaves; this finding corresponded to a concomitant increase in monocytes (young cells) which contain the greatest quantity RNA. Baranski (42) detected various leukocyte shifts in workers exposed for one year to microwaves. Normalization of this index was found to occur after prolonged exposure to this factor. He also found a tendency towards lymphocytosis with accompanying eosinophilia in subjects exposed for more than five years to low and moderate microwave intensities.

TABLE 8

Neurohumoral responses to radiofrequency electromagnetic radiation

1. Altered cholinesterase activity in human whole blood (erythrocytes)
2. Decrease in blood histamine content
3. Increase in blood proteins
4. Altered carbohydrate metabolism
5. Changes in blood sugar, cholesterol, and lipids (pronounced in diabetics)
6. Decreased hemoglobin

Soviet workers have also found biochemical changes to occur in other sites (8). A drop in RNA content was noted in the spleen, liver, and brain in animals chronically exposed to microwaves while DNA content was found to remain constant.

Ocular Responses

Changes in human ocular function and eye pathology are widely documented and occur primarily

TABLE 9

Distribution of pyruvic and lactic acid and creatinine excretions in workers exposed to microwaves

	Pyruvic acid		Lactic acid		Creatinine	
	number	%	number	%	number	%
No. of measurements	40	100.0	35	100.0	34	100.0
Normal	28	70.0	14	40.0	14	41.2
Increased	4	10.0	6	17.2	6	17.6
Lowered	8	20.0	15	42.8	14	41.2
Averages	0.77 mg%		14 mg%		1.33 mg%	
Controls	0.65 mg%		17 mg%		1.30 mg%	
Established standard	0.5—1.0		10—20		1.2—1.9	

after acute or chronic exposure to thermogenic microwave intensities (Table 11). As mentioned earlier, one Soviet worker (28) has reported that exposure to intense microwave fields was noted to cause hallucinations. Matuzov (29) found the area of the blind spot to decrease after exposure to nonthermogenic (10 cm; 1.1 mW/cm²) microwave field intensities. Other Soviet workers, as reported by Marha (8), have found that microwave radiation (a few mW/cm²) can cause a decrease in sensitivity to color (blue) and difficulty in detecting white objects. Changes in intraocular pressure have also been noted by Soviet workers as have altered sensitivity to light stimuli during exposure to pulsed and nonpulsed fields. General ocular pain, eye strain and fatigue, eyelid tremor, and lacrimation are also common symptoms noted by Soviet workers.

Pathological changes in the eye (cataracts) occur primarily as a result of exposure to thermogenic (greater than 10 mW/cm²) microwave intensities. Sadchikova (45) and other Soviet workers (6) have noted unilateral and bilateral cataracts to occur in subjects exposed to several mW/cm² field intensities. Presman (44) noted a drop in vitamin C content in the lens and anterior chamber fluid at nonthermogenic intensities. In the event of acute cataract development a decrease in ATP and pyrophosphatase activity of the lens was noted. In addition, it is suspected that damage to tissue respiration and oxidation mechanisms as a result of exposure to microwaves can lead to cataract formation.

There is some evidence that ocular responses to microwaves are frequency dependent. Pol (46) noted that 10 GHz fields caused anterior lens opacity while 2.45 GHz cause posterior opacity.

Belova (47) noted that in 370 microwave generator workers exposed to mW/cm², lacrimation, ocular fatigue, and frequent conjunctival irritation would occur at the end of each working day. Zydecki (48) suggested that all candidates for occupation around microwave sources receive comprehensive ophthalmological examinations. This suggests that certain ophthalomological profiles might be more vulnerable to microwave radiation than others.

TABLE 10

Hematopoietic and biochemical responses to electromagnetic radiation

1. Blood
   a. reticulocytosis
   b. basophilic granularity of erythrocytes
   c. decrease in erythrocytes, platelets and hemoglobin
   d. altered osmotic resistance of erythrocytes
   e. neutrophilic leukocytosis
   f. lymphocytosis, monocytosis, and eosinophilia
   g. increased RNA in lymphocytes
2. Organs
   a. Decreased RNA content in brain, liver, and spleen

Endocrine Responses

Damage to sex glands and functions have frequently been documented to occur after chronic exposure to primarily thermal microwave fields (Table 12). Marha (8) in reviewing Soviet and East European findings noted decreased spermatogenesis, altered sex ratio of births, changes in menstruation, retarded fetal development, congential effects in newborn babies, decreased lactation in nursing mothers, and other related responses to occur as a result of exposure to thermal (i.e., greater than 10 mW/cm^2) microwave intensities. Microwaves were also implicated in an increase in the percentage of miscarriages in both humans and animals. Some of these

TABLE 11

Effects of electromagnetic radiation on the eye

1. Perceptual and function changes
   a. hallucinations
   b. decrease in size of blind spot
   c. decreased sensitivity to color (blue)
   d. difficulty in detection of white objects
   e. decreased sensitivity to light stimuli in dark adapted eye
   f. change in intraocular pressure
   g. lacrimation, ocular fatigue, and ocular pain
   h. trembling of the eyelids
   i. altered tissue respiration and oxidation-reduction processes
2. Pathological changes
   a. lens coagulation (cataracts)
   b. decrease in vitamin C content of lens and vitreous humor
   c. decrease in ATP and pyrophosphinatase activity
   d. anterior and posterior lens opacity
   e. conjunctival irritation

findings reported by Marha are consistent with subjective complaints reported by Soviet researchers such as decreased sex activity, mentioned earlier. Specific genetic changes resulting from exposure to either thermal or nonthermal microwave fields have yet to be demonstrated.

Soviet sources have reported pituitary and other endocrine responses to microwave exposure. Kolesnik (49) suggested that pituitary-hypophyseal-adrenal changes were primarily due to CNS influences on the hypophysis after exposure to microwaves. Drogichina (33, 50), Sadchikova (21, 34), and Smirnova (51) have reported thyroid gland enlargement and increased iodine-131 uptake. These changes suggest an increase in thyroid stimulating hormone (6). Hasik (40) and Presman (44) noted increased activity of the adrenal cortex to occur after microwave exposure. Murashov (52) studied 20 subjects occupationally exposed to UHF fields. He noted a reduction in plasma corticosteroid content which was attributed to lowered adrenal, or possibly sex gland androgenic activity.

TABLE 12

Endocrine responses to radiofrequency radiations

1. Sex organs and ontogenesis
   a. thermal trauma (tissue damage) to male reproductive tissues
   b. decreased spermatogenesis (sterility)
   c. altered sex ratio of births (more girls)
   d. altered menstrual activity
   e. altered fetal development
   f. decreased lactation in nursing mothers
2. Endocrine glands
   a. altered pituitary and pituitary-hypophyseal function (CNS)
   b. hyperthyroidism
   c. thyroid enlargement
   d. increased iodine-131 uptake
   e. increased adrenal cortex activity
   f. decreased corticosteroids in blood
   g. decreased glucocorticoidal activity

Miscellaneous Responses

Loshak (53) reported that various human responses, such as subjective complaints as a result of chronic microwave exposure, appeared to vary slightly with climate (Table 13). In general, responses to microwave fields were more pronounced in hot, dry climates. It was found that the electrical resistance of the skin of exposed workers was lower than in unexposed workers in a hot climate. Decreased resistance was attributed both to CNS stimulation or increased sympathetic tonus due to skin receptor reactions. These findings, while not dramatic, led Loshak to speculate that special hygienic considerations for workers exposed to microwaves in a hot climate should be exercised (improved ventilation etc.).

TABLE 13

Miscellaneous effects on electromagnetic radiation

1. Climatic effects
   a. responses to electromagnetic radiation more pronounced in hot climate
   b. decreased electrical resistance of skin in hot climate due to electromagnetic radiation
2. Internal Organs
   a. dyspepsia and epigastric pain
   b. decreased appetite
   c. liver enlargement