5D.5 SLIGHT ATMOSPHERIC PRESSURE FLUCTUATIONS AS THE RISK FACTOR PROMOTING AGGRESSIVE BEHAVIOUR

Lyudmyla Didyk[1], Yuriy Gorgo[1], Sergey Mamilov[1], Irina Semenova[2]

[1] Institute of Applied Problems of Physics and Biophysics, National Academy of Sciences of Ukraine, Kyiv, Ukraine
[2] Department of Pediatric, Social and Forensic Psychiatry, P.L. Shupyk National Medical Academy of Postgraduate Education, Kyiv, Ukraine

1. INTRODUCTION

Atmospheric pressure fluctuations (APF) are considered to be an adaptive meteorological factor, influencing human health, psychical and physical state, and behaviour. Particular interest is the meteorotropic features of the APF with periods from seconds to deco-minutes related to the acoustic and internal gravity waves phenomena. Acoustic waves are produced by air compressibility while the internal gravity waves (IGW) exist by virtue of the stable density stratification of the atmosphere under gravity. Most powerful source of APF in stormy weather is the chaotic turbulent airflows induced by strong wind, Gossard, Hooke (1975), Lumley, Panofsky (1964). The APF in the acoustic frequency range are mainly due to wind induced turbulence. The IGW at lower level of the atmosphere are also generated a varying number of sources including convective and frontal activity, wind shear and topography. It was found that under Foehn conditions the amplitude of gravity waves is increased, while acoustic waves are highly damped, Richner (1977). APF are also linked with the other geophysical factors as well as the solar activity influencing the weather-forming processes in the atmosphere.

Several studies have shown that the mechanisms of attention and the autonomic nervous systems, providing for purposeful activity, are most sensitive to APF, Kolosova, Mindlina (1987), Didyk, et.al (2000). The common normal levels of APF with periods from 3 s to 120 s, attributed to far infrasound range (APF-I), are considered to be a stimulating factor for human mental and physical activity. Meanwhile, their high level is a risk factor resulting in the additional strain for adaptation mechanisms. Such APF-I can increase mental and physiological strain, creating potential danger for a failure of the adequate behaviour resulting in injuries occurrence. For example, our previous study shows the increase in the sport injuries number on days with APF-I high level compared to their normal low level, Didyk, et.al (2012).

In contrast, the same high level APF with longer periods related mostly to IGW range (APF-G: 120 s < T < 1200 s) is rather a weak physical factor, which have the activating influences on normal human activity. As a result of their effects the decrease in sport injuries number is documented on days with high APF-G and low APF-I levels.

It follows from the previous studies that the high APF-G as well the low APF-I being an activating factor can also promote the human aggressive behavior. Meanwhile, the high APF-I disrupting effects on people purposeful activity is positive factor favoring to decrease in risk of aggressive actions.

The purpose of this study is to verify hypothesis that there is the relation between APF physical characteristics and criminal aggressive behavior with injury consequences, and to analyze the physical characteristics of natural APF from view of their possible effects on the aggressive behaviour.

2. METHODS

The study was conducted in Kyiv city (Ukraine). The continuous measurements of atmospheric pressure were carried out every 0.5 s with a standard high sensitive (1 Pa) microbarometer outdoors.

These monitoring data during the one-year period (from 1 July 2005 to 30 June 2006) are used for the analysis. The APF spectral parameters and average hourly integral amplitude (HA) in two ranges of periods (HAI: 3 s - 120 s and HAG: 120 s - 1200 s), as well the daily mean of HAI (DHAI) and HAG (DHAG) were calculated with a special computer program developed by us using Matlab software. According to known definitions the APF periods are related primarily to the far infrasound in the first range (thereafter I-range) and to IGW in the second range (thereafter G-range).

The previous studies revealed the threshold effects of the DHAI and DHAG, above which the physiological and behavioural responses were observed. Therefore, the DHAI and DHAG values were divided into two categories: the high, when they exceeded the threshold criteria related to sport injury occurrences (3.9 Pa and 2.4 Pa, respectively), and the low for the other less values.

These criteria with the database on the DHAI and DHAG values, and concomitant meteorological variables, particularly the wind velocity (WV) within the interval analyzed are applied to examine the hypothesis that a relation exists between APF and a daily number of emergency transport events due to human criminal behaviour related to injury occurrences (EECI). For that the data on EECI from 1 July 2005 to 30 June 2006,

* *Corresponding author address: Didyk L.A.* Institute of Applied Problems of Physics and Biophysics, National Academy of Sciences of Ukraine, Kyiv, Ukraine; e-mail: la_didyk@iop.kiev.ua

obtained from the Kyiv Station of emergency services and medicine of catastrophes, are considered.

Since the APF are causally related to the wind induced turbulence, the additional analysis of possible association of the DHA effects with wind velocity (WV) was performed in detail.

All variables are not normally distributed. Therefore, non-parametric (Mann-Whitney U-test and Sherman rank correlation test) estimations were applied. Statistical analysis was performed with Matlab 6.6 (Curve Fitting Toolbox), Statistica 6 and MS Excell.

3. RESULTS & DISCUSSION

Comparative analysis of DHAI (95% CI: 2.65 – 3.06 Pa, n = 345) and DHAG (CI: 2.27 – 2.50 Pa, n = 345) values with their threshold criteria (3.9 Pa and 2.4 Pa, respectively) indicates prevalence of their common low levels in an atmosphere within the one-year interval analyzed (the number of days for the DHAI and DHAG low levels: n = 254 and n = 214, respectively against their high levels n = 91 and n = 131, respectively).

At this atmospheric background the EECI number proved to be significantly greater on days with the high DHAG and low DHAI values (CI: 48.8 – 53.7, n = 75) when compared to days with the high DHAI (CI: 44.7 – 49.1, n = 72, p = 0.012).

These findings are in line with the suggestion that activating influences of the high APF-G as well as the low APF-I, but not the high APF-I, promote human inadequate aggressive actions. Such a peculiarity of effects for two frequency ranges is likely linked to the frequency-dependent human sensitivity, resulting in the distinctive response. According to this, the APF with larger periods as in the G-range is rather a weak physical factor capable for only activating effects. Meanwhile, the high DHAG activating effect fails to occur under high DHAI conditions when mechanisms of adaptation are already overstrained by this additional physical environmental factor.

It is believed that APF is the physical agent responsible, at least partially, for biological response to other geophysical factors related to APF origination, particularly wind-induced turbulence. Our analysis show the higher correlation between the APF-I and WV yearly dynamics (r = 0.72 p = 0,000) than between the APF-G and WV (r = 0.49, p = 0,000). These findings corroborate the more pronounced causal relations of WV with the

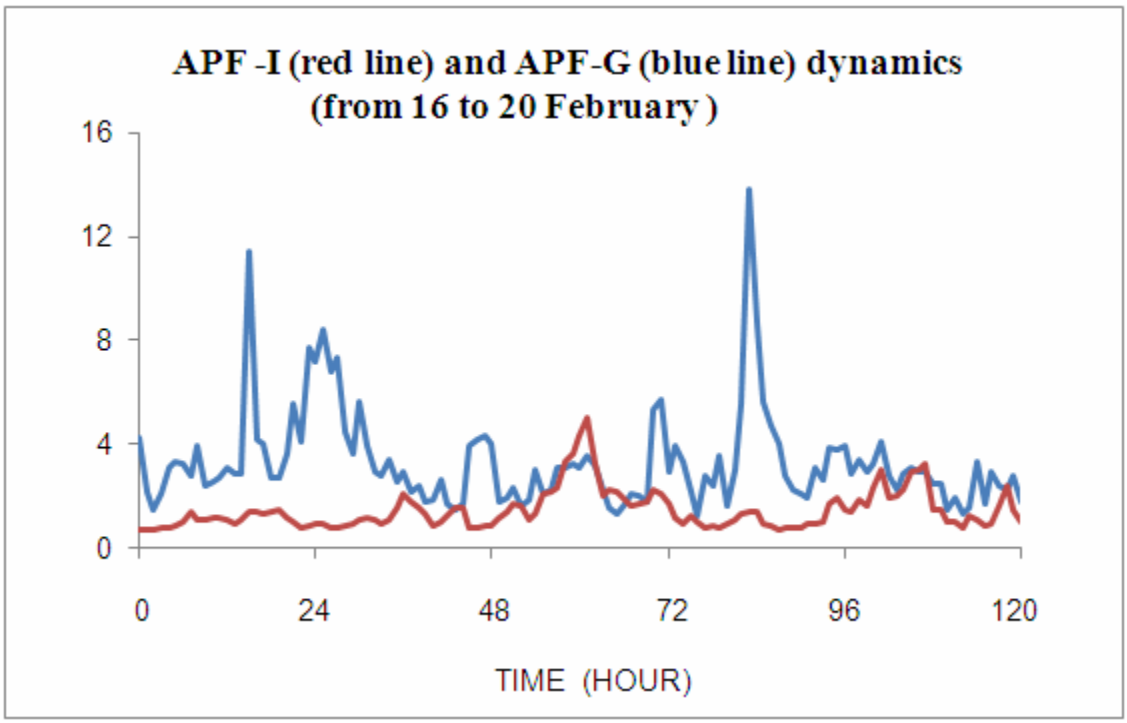

Fig. 1. The dynamics of APF-I and APF-G average hourly integral amplitude within the five days interval.

APF-I, than with the APF-G.

Of interest are the facts, that within the five days interval, when the highest hourly values of APF-G were observed on the background of the low APF-I (Fig. 1), the correlation between hourly dynamics of APF-I and APF-G, as well as between APF-G and WV dynamics proved to be below of the level of significance (r = - 0.17, p = 0.3 and r = - 0.067, p = 0,68, respectively),

while the significant correlation is shown between APF-I and WV dynamics (r = 0.56, p = 0,0002). These facts evidences once more in the favor of causal relations between APF-I and WV, while the high level APF-G are more associated with the other physical sources.

It is believed that natural APF could affect the human body through the ear, Green, Dunn (1968). In favor of this view the mechanical reactions of pars flaccida in response to very little changes in the middle ear pressure, as well as to slight pressure oscillations in far infrasound range were demonstrated by the experimental studies on animals, Dirckx, et.al (1998), Didyk, et.al (2012).

We suggest that APF may influence the inner ear, too. The pressure transmission from the external ear canal to the inner ear is well studied in the otolaryngology. Particularly, it is established that a linear relationship exists between the amplitudes of pressure periodic changes in the inner ear and external ear canal of at least within the +/− 200 mmH2O (≈2000Pa) ranges Gyo, et.al (1988). Some authors believe that there is a pathway, through which changes in the pressure are transmitted from the middle ear to the inner ear and influence the activity of the otolithic receptors. This activity consequently affects the firing rates of the vestibular afferent fibers and of the neurons in the vestibular nucleus, Naito et.al (1988). Vestibular labyrinth is exquisitely sensitive to changes in endolymph pressure. The most sensitive primary afferents respond to changes in endolymph pressure as low as 0.005 Pa. Obviously, the deterioration in mental performance and autonomic indices under exposition of simulated APF-I, observed by Delyukov, Didyk (1999), is linked with the influence of upward vestibular fibres on brainstem reticular activating systems and cortex. It is also shown that vestibular activity is dependent on the rates of ambient pressure changes in the middle ear. It is larger under higher rates of pressure changes, Suzuki, et.al (1995). May be different effects of high APF in two frequency ranges revealed in the present study are to some extent connected with this peculiarity of vestibular response.

As to the human response, other natural physical environmental variables can contribute to combined effects. Several studies demonstrated significant relations between the atmospheric pressure and gravity oscillations in the G-range. There is also the concept that changes in the middle ear pressure stimulate otolithic hair cells through the same mechanism as in gravitational forces, Naito (1988). The otolith organs that sense the gravitoinertial forces transform them into a neural code for CNS controlling balance and equilibrium mechanisms, and providing the adequate physiological adaptation to gravity changes. Adaptation to altered gravity in the short term (seconds to hours) happens every day when we wake up and stand up, as well as during the riding a bicycle, speeding in a fast car, flying in an airplane, whizzing downhill on a sled, the motion of rocking or rotation, which stimulate the inner ear gravity sensors. Numerous studies have examined the biological effects of large changes in earth's gravity, such as exposure to microgravity in spaceflight, or to hypergravity induced by spacecraft launch or centrifugation. According to our knowledge, the threshold of human sensitivity to small gravity changes is not determined. It is ambiguous, whether the gravity oscillations caused by some geophysical phenomena, particularly by the atmospheric disturbance, can be biologically significant physical factor. Allowing for the high sensitivity of inner ear mechanisms to the gravity, it may be suggested that natural gravity oscillations in certain conditions can reach the level of biological significance, and add to the effects of APF.

To conclude, the present study contributes to the understanding of psychotropic effects of APF. It seems, that certain physical characteristics of this atmospheric factor present risk for the increase in the level of aggression and as a consequence in the number of injured victims. It also follows from this as well as from former studies that further investigations is needed to clear up the question on relationships between the APF and other biologically significant geophysical as well as cosmic factor

4. REFERENCES

Gossard, E.E., Hooke, W.H., 1975: Waves in the atmosphere: atmospheric infrasound and gravity waves – their generation and propagation. Elsevier Scient. Publ. Comp., Amsterdam–Oxford–New York.

Green, J.E., Dunn, F., 1968: Correlation of naturally occurring infrasonics and selected human behavior. *J. Acoustic. Soc.*, 44, 1456–1457.

Gyo, K., Nishihara, S., Yanagihara, N., 1988: Pressure transmission properties from the external ear canal to the inner ear. *Acta Otolaryngol.*, (Stockh), Suppl, 456, 87–91.

Delyukov, A., Didyk, L., 1999: The effects of extra-low-frequency atmospheric pressure oscillations on human mental activity. *Int. J. Biometeorol.*, 43, 31–37.

Didyk, L.A., Delyukov, A.A., Gorgo, Yu.P., Semenova, I.A., 2000: The influence of extralow frequency fluctuations of atmospheric pressure on voluntary attention parameters. *Human Physiology*, 26(4), 55–60.

Didyk, L.A., Bogdanov, V.B., Lysenko, V.A., Didyk, N.P., Gorgo, Yu.P., Dirckx, J.J.J., 2007: The effects of slight pressure oscillations in the far infrasound frequency range on the pars flaccida in gerbil and rabbit ears. *Int. J. Biometeorol.*, 51, 221–231.

Didyk, L., Gorgo, Yu, Prigancova, A., Tuny, I., Vaczyova, M., Mamilov, S., Dirckx, J., 2012: The effects of atmospheric pressure fluctuations on human behaviour related to injury occurrences: study on the background of low and moderate levels of geomagnetic activity. *International Scholarly Research Network ISRN Meteorology*, 1–8, doi:10.5402/2012/791524.

Dirckx, J.J.J., Decraemer, W.F., von Unge, M., Larsson, C.H., 1998: Volume displacement of the gerbil eardrum pars flaccida as a function of middle ear pressure. *Hear. Res.*, 118, 35–46.

Kolosova, O.A., Mindlina, G.E., 1987: The influence of meteoro- and helio-factors on the state of human autonomic nervous system and adaptive capabilities a

review (In Russian). *Zh Neuropatol Psikhiat Im SS Korsakova*, 87(1), 136–141.

Lumley, J.I., Panofsky, H.A., 1964: The structure of atmospheric turbulence, Interscience publishers. A division of John Wiley and Sons, New York–London–Sydney.

Naito, Y., Ito, J., Tsuj, J., Honjo, I., 1988: The influence of middle ear pressure on the otolith system in cats. *Arch. Otorhinolaryngol*., 245, 321–324.

Richner, H., 1977: Pressure fluctuations caused by atmospheric waves and their variation under different conditions. *Arch. Met. Geoph. Biokl., Ser. A,* 26(4), 309-322.

Suzuki, M., Kitano, H., Yazawa, Y., Kitajima, K., 1995: The influence of rates of pressure change on pressure-induced vestibular response in guinea pigs. *Nippon Jibiinkoka Gakkai Kaiho*, 98(5), 820–824.