Spontaneous Ultra-Weak Photon Emission from Human Hands Is Time Dependent

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Abstract. *Ultra-weak photon emission in the visible range was measured on palm and dorsal side of left and right hand by means of a low noise photomultiplier system. To study the dynamics of this photon emission in a 24 h period photon emission was recorded in 2 h intervals in 5 experiments, utilizing strict protocols for dark adaptation and recording of subjects.*

Fluctuations in photon emission in the course of 24 h period were demonstrated for each anatomic location. Mean photon emission over the 24 h period differed both between subjects and hand locations. To detect a pattern in the fluctuations the mean value for each location of each subject in each experiment was utilized to calculate fluctuations during the course of 24 h for each anatomical location.

The fluctuations in photon emission in the course of 24 h were more at dorsal sides than palm sides. The correlation between fluctuations in palm and dorsal side was not apparent. During the 24 h period a change in left-right symmetry occurred for the dorsal side but not for the palm of the hands. Photon emission at the left dorsal location was high at night, while the right dorsal side emitted most during the day.

It is concluded that a daily rhythm in photon emission can be recorded from both the dorsal and palm sides of the hands.

Keywords

Biophoton, ultra-weak photon emission, biophotonics, hand dorsum, palm, left-right symmetry, hand.

1. Introduction

Fröhlich postulated coherent electrically polar longitudinal vibrations in biological systems [1-4]. Electrically polar vibrations generate electromagnetic field [5]. In eukaryotic cells polar vibrations in microtubules of the cytoskeleton are excited by energy supply [6], [7]. Electromagnetic field is generated in a very wide range of frequencies as was predicted by Fröhlich [4]. The oscillations in acoustic [8], megahertz [9], gigahertz [10] and far infra red [11] range were detected. Photon emission is measured in the visible and UV range of the electromagnetic spectrum [12-17].

Living biological systems, including humans, constantly and spontaneously emit a very small amount of photons in the visible and UV part of the electromagnetic spectrum (200-800 nm) [12-17]. Terms such as ultra-weak photon emission and spontaneous ultra-weak, low-level, or dark bio-/chemi-luminescence or biophoton are used to describe this phenomenon.

Human ultra-weak photon emission (UPE) is not seen by unaided eye due to its ultra low intensity, of order of 100-1 photons/s.cm^2, corresponding to 10^{-16} – 10^{-18} W/cm^2. The threshold sensitivity of a human eye can be individually different, and ranges from 10^6 - 10^4 photons/s.cm^2 (10^{-12} - 10^{-14} W/cm^2).

There already has been some work done on spatial mapping of photon emission intensity [18-20] and it was found that there exists a typical anatomic "pattern" of photon emission. Temporal variations of photon emission intensity have been observed on the time scale of weeks and months [21], [22].

Photon emission displays fluctuations in subsequent dwell periods, but already a few minutes of measurement yields a reliable mean value of intensity [19]. When photon emission intensities over periods of hours were compared, their fluctuations demonstrated the instability of the complex biological system [19]. However, fluctuations or rhythms during the day have not been studied systematically.

Spectral analysis of spontaneous emission is commonly utilized to identify the molecular origin of photon emission. Experimental evidence cumulated, to date, has indicated that the spectrum is in the wavelength range between 430 and 650 nm [19] corresponding to spectra obtained from carbonyl compounds in the excited singlet and triplet states and excited dimers of singlet molecular oxygen [23]. Such compounds are formed during the decomposition of lipid peroxides. Lipid peroxides are very common emitters of ultra-weak low emission. A perspective for a non-invasive diagnostic tool may be created with the further research and gathering the necessary set of data.

The present paper reports on the fluctuations in spontaneous photon emission from human subjects in the period of hours, recording the photon emission in regular time intervals during day and night.

2. Materials and Methods

2.1 Measurement System

A special darkroom (2m x 2m x 1m) and photon counting device were used to record photon emission of the subjects. Walls and ceiling of that darkroom were covered with black matt paint. The temperature of the dark room was registered before and after every set of measurement. The darkroom could be vented. The darkroom had a bed inside and subjects could be easily measured in lying or sitting position. The darkroom was built inside a control room without windows, and separated by a light tight door and black matt curtain to ensure that there is no light leakage to the dark room. The control room contained the electrical equipment (high voltage supply for photomultiplier tube (PMT), PMT shutter and steering system), an active air moisture filter, a cooling unit for PMT as well as a remote computer system for the photomultiplier. The control room was illuminated by red light.

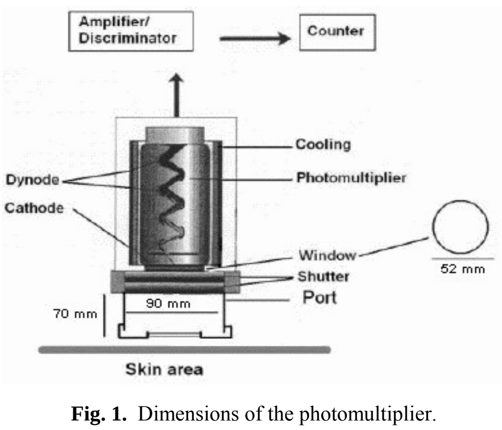

Fig. 1. Dimensions of the photomultiplier.

The photomultiplier tube (EMI 9235 QB, selected type) used could be manipulated in three directions. It is a 52-mm diameter, especially selected, low noise, end window photomultiplier that was mounted in a sealed housing under vacuum with a quartz window. An additional ring at the front of the photomultiplier tube allowed measuring a 9-cm-diameter area at a fixed distance from the body (70 mm) – see Fig. 1. The photomultiplier had a spectral sensitivity range of 160–630 nm with two peaks of 30% on 200 nm and 400 nm. It was maintained at a low temperature of –25 °C in order to reduce the dark current (electronic noise). The typical dark current (electronic noise) under these conditions was about 5 counts per second (cps). The exact value of the dark current was measured before and after each measurement of spontaneous photon emission and then subtracted to gain the actual photon emission.

2.2 Measurement Protocol

The protocol included the setting and timing for the experiment. Subjects were self-reportedly healthy and non-smokers. Between the measurements, the subjects kept their normal activities. Subjects were dark accommodated for at least 1 hour prior to measurement. Practically, the subjects were staying in the dim red light of the control room. The final part of dark accommodation included a 10 min period in the darkroom in the same position as the measurement was carried out to avoid changes in photon emission due to abrupt change of body position. Subjects were measured every two hours in time span of 24 hours. Measurements were carried out on palm and dorsal sides of both hands.

2.3 Processing of the Data

Data from each measurement have been automatically stored by software for the operation of photomultiplier and counting system. Specified scripts of Python programming language are utilized for data processing and evaluation. MS Office – Excel and Statistica 6.0 were utilized for statistical analysis and representation of data in graphs and charts.

3. Results

Five experiments of whole day (24 hours long) photon emission measurements were analyzed for (a) mean photon emission of different anatomical locations in individual experiments, and (b) fluctuations in time of the day. Mean values for photon emission are presented in Tab. 1. Commonly, palm locations show higher emission than dorsal locations. Differences in emissions between left and right locations were also observed but were less obvious than emission between palm and dorsal sides.

To study common fluctuations in time, data were normalized. The mean over 24 h, taken as 100%, was used to normalize the photon count values of each measurement series. Then, for each time point the mean over the 5 experiments was calculated. The fluctuations in mean emission intensity of the hand based on measurements of all hand locations and all experiments at different times (n=60) are presented in Fig. 2.

The fluctuations in mean emission intensity of the hand based on measurements of all hand locations and all experiments at different times (n=60) are presented in Fig. 2. These data show that mean emission of the hand is low during the day, rises during the evening and remains high during the night. It decreases in the early morning. The first measurement is an exception.

Mean ± SEM				
Experiment n.	Left palm	Left dorsum	Right palm	Right dorsum
1	5.68 ± 0,25	3.54 ± 0,16	7.34 ± 0.34	4.24 ± 0.20
2	5.00 ± 0.17	2.28 ± 0.12	6.29 ± 0.24	3.16 ± 0.22
3	4.69 ± 0.19	2.24 ± 0,21	4,57 ± 0.22	2.62 ± 0,18
4	5.63 ± 0.31	2.60 ± 0,19	7.10 ± 0.29	3.95 ± 0.26
5	6.98 ± 0.57	3.73 ± 0.40	7.46 ± 0.46	3.78 ± 0.22

Tab. 1. Mean values of photon emission [counts/s] from all experiments and locations.

Fig. 2 also presents the fluctuations in emission for both dorsal and both palm locations, separately. Data demonstrate that both sides of hands show qualitatively similar emission patterns during the day. Quantitatively, the emission from dorsal locations fluctuates more than the emission from palm locations during the day.

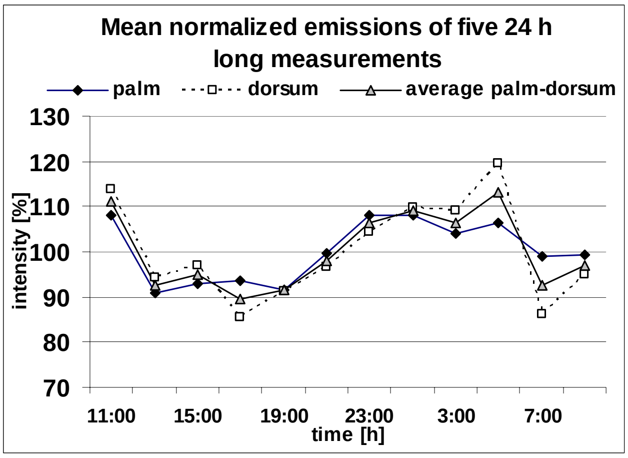

Fig. 2. Mean normalized emissions of the five 24 h long measurements (11:00-9:00) Every two hours left and right palm as well as dorsal sides of the left and the right hand were measured. The data are shown for all locations (average palm-dorsum), and for palm (palm) and dorsal (dorsum) sides separately.

Finally, the fluctuations in mean (normalized) emission intensity are calculated for both locations of the left hand and both locations of the right hand (Fig. 3). The data demonstrate that larger fluctuations occur in emissions of the left hand than those of the right hand.

Left-right symmetry of emission during the day was studied. Two types were calculated: (a) left-right symmetry of palms, and (b) left-right symmetry of hand dorsum. To determine left-right symmetry, the difference in emissions between left and right locations was calculated for each time of the day. The data are presented in Fig. 4.

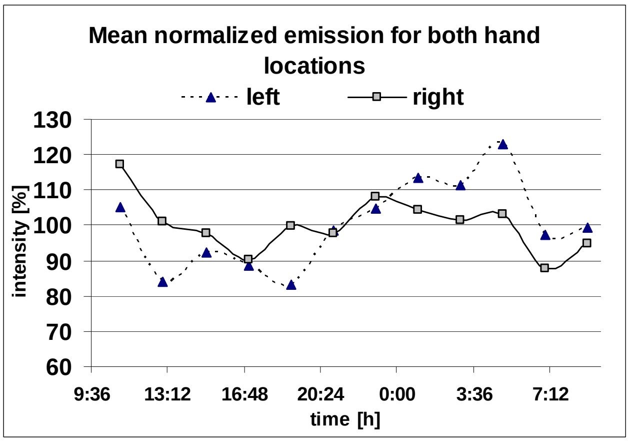

Fig. 3. Mean normalized emissions of the five 24 h long measurements (11:00-9:00) Every two hours left and right palm as well as dorsal sides of the left and the right hand were measured. The data are shown for both left hand locations (left) and both right hand locations (right).

The data suggest a shift in asymmetry during the day. In the period that average emissions are low (lower than the normalized value of 100%) the left sides emissions were less than the right side emissions. In the periods where the average emissions are higher than the 100% mean value the left sides emitted more than the right sides. However, the shift in relative emission intensities does not correspond perfectly to the shift in left-right asymmetry. To substantiate this conclusion however, more experiments are necessary.

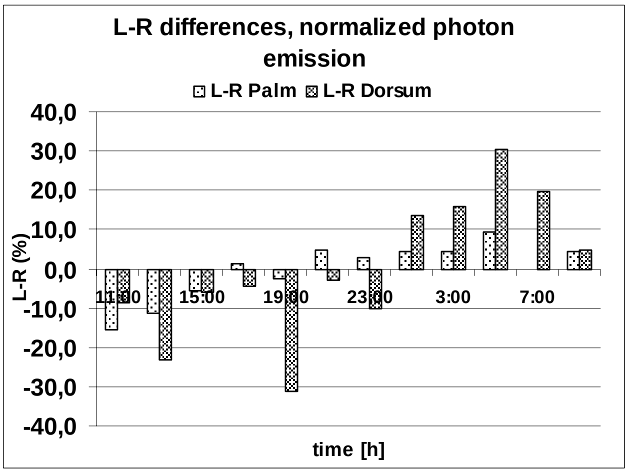

Fig. 4. Left-right differences in emission for palm and dorsal sides of the hands during the day calculated from the mean photon emission for each time period.

Finally, it was apparent that the asymmetry of dorsal sides was greater than the asymmetry of palm sides.

The shift in the left-right asymmetry was analyzed by the utilizing a T-test of dependent samples. Comparing the L-R values of the palms in the period 11.00- 21.00 h with values in the period 23.00 – 9.00 h, they showed mean emission of –4.73 ± 3.11 and +4.21 ± 1.28, respectively. This difference was significant (p=0.030). The L-R values for the dorsum in the same periods were –12.65 ± 4.79 and +12.37 ± 5.61, respectively (p=0.026).

4. Discussion

A 2 h sampling period in a 24 h experiment is on the edge of the feasibility of the study, without violation of physiology of subjects. In a study on rhythmic patterns of spontaneous emission, a frequency of sampling must be selected that allows, on the one hand, registration of as many time periods within the 24 h experimental period as possible, and, on the other hand, to keep physiological conditions between recording periods. However, these two variables act in an opposite manner: a higher frequency increases the accuracy of the pattern, but violates physiological conditions. Therefore, the protocol was limited to a 2 h sampling period. Each recording period included a 10 min physiologic adaptation in the dark room followed by the recording of the four anatomic locations.

The number of subjects in this pilot study was limited. However, data evaluation yielded interesting and useful results even from this small group of subjects. The data suggest that this protocol is sufficient for an accurate study on the issue of diurnal rhythms in human ultra-weak photon emission.

It is concluded that intensity as well as left-right symmetry vary diurnally, suggesting similar fluctuations in endogenous pro- and anti-oxidative capacities. A few studies have focused on such diurnal rhythms. It has been estimated in rats that lipid peroxidation levels increased progressively during the night and started to decline in the morning [24[, [25].

5. Conclusion

The aim of this experimental work was to collect more information about the dynamics of human photon emission fluctuations in the interval of 24 hours, since the data concerning dynamics of human photon emission found in the literature are rather scarce and oriented more on the long term observation in time intervals of weeks and months.

It was found that observed diurnal fluctuations of the photon emission intensity as well as left-right asymmetry are not negligible. The knowledge about diurnal rhythms in photon emission intensities and symmetry are crucial for evaluation of any further experiments that rely on comparison between left and right anatomical locations, particularly in the case of left-right asymmetries in patients [21], [22] to avoid false conclusions.

If, however, this peculiar rhythm is better understood through further research, this new set of data may serve as a perspective for a non-invasive diagnostic tool.

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References

[1] FRÖHLICH, H. Bose condensation of strongly excited longitudinal electric modes. *Phys. Letters Ser. A*, 1968, vol. 26, p. 402-403.

[2] FRÖHLICH, H. Long-range coherence and energy storage in biological systems. *Intern. J. Quantum Chem.*, 1968, vol 2., p. 641-649.

[3] FRÖHLICH, H. Quantum mechanical concepts in biology. In. *Theoretical Physics and Biology (ed. M. Marois), Proceedings of 1st International Conference on Theoretical Physics and Biology. Versailles, 1967.* 1969, p. 13-22.

[4] FRÖHLICH, H. The biological effects of microwaves and related questions. *Advances in Electronics and Electron Physics,* 1980, vol. 53, p. 85-152.

[5] POKORNÝ, J., WU, T.-M. *Biophysical Aspects of Coherence and Biological Order*. Praha (Czech Republic): Academia, Berlin-Heidelberg-New York: Springer, 1998.

[6] POKORNÝ, J. Viscous effects on polar vibrations in microtubules. *Electromagnetic Biology and Medicine,* 2003, vol. 22, p. 15-29.

[7] POKORNÝ, J. Excitation of vibration in microtubules in living cells. *Bioelectrochemistry,* 2004, vol. 63, p. 321-326.

[8] PELLING, A. E., SEHATI, S., GRALLA, E. B., VALENTINE, J. S., GIMZEWSKI, J. K. Local nanomechanical motion of the cell wall of Saccharomyces cerevisiae. *Science,* 2004, 305, p. 1147-1150.

[9] POKORNÝ, J. , HAŠEK, J., JELÍNEK, F., ŠAROCH, J., PALÁN, B. Electromagnetic activity of yeast cells in the M phase. *Electro- and Magnetobiology*, 2001, vol. 20, p. 371-396.

[10] JELÍNEK, F., POKORNÝ J., ŠAROCH, J., HAŠEK, J. Experimental investigation of electromagnetic activity of yeast cells at milimeter Wales. *Electromagnetic Biology and Medicine,* 2005, vol. 24, no. 3, p. 301-307.

[11] VOS, M. H., RAPPAPORT, F., LAMBRY, J.-C., BRETON, J., MARTIN, J.-L. Visualisation of coherent nuclear motion in membrane protein by femtosecond spectroscopy. *Nature,* 1993, 363, p. 320-325.

[12] BELOUSSOV, L., POPP, F. A *Biophotonics: Non-equilibrium and Coherent Systems in Biology, Biophysics and Biotechnology.* BioInform services, Moscow. 1996.

[13] POPP, F. A., LI, K. H., GU, Q. *Recent Advances in Biophoton Research and its Applications.* World Scientific Publishing, 1992.

[14] BELOUSSOV, L., POPP, F. A., VOIEKOV, V., VAN WIJK, R. *Biophotonics and Coherent Systems.* Moscow University Press, 2000.

[15] POPP, F. A., BELOUSSOV, L. *Integrative Biophysics – Biophotonics.* Kluwer Academic Publishers, 2003.

[16] SHEN, X., VAN WIJK, R. *Biophotonics – Optical Science and Engineering of the 21st century.* Spinger, 2005.

[17] BELOUSSOV, L. V., VOEIKOV, V. L., MARTYNYUK, V. S. *Biophotonics and Coherent Systems in Biology.* Springer, 2006.

[18] VAN WIJK, R., KOBAYASHI, M., VAN WIJK, E. P. Anatomic characterization of human ultra-weak photon emission with a moveable photomultiplier and CCD imaging. *Journal of Photochemistry and Photobiology B.*, 2006, Apr 3, vol. 83(1), p. 69-76.

[19] VAN WIJK, R., VAN WIJK, E. P. Multi-site recording and spectral analysis of spontaneous photon emission from human body. *Forschende Komplementärmedizin und Klassische Naturheilkunde,* 2005, 12, p. 96–106.

[20] KOBAYASHI, M. Two-dimensional imaging and spatiotemporal analysis of biophoton imaging technique and applications for biomedical imaging. *Biophotonics – Optical Science and Engineering of the 21st century.* Eds. Xu Shen, Roeland Van Wijk. Springer, 2005, p. 155.

[21] COHEN, S., POPP, F. A. Biophoton emission of the human body. *Journal of Photochemistry and Photobiology B: Biology,* 1997, 40, p. 187-189.

[22] JUNG, H-H., WOO, W-M., YANG, J-M., CHOI, C., YANG J-S., SOH, K-S. Year-long biophoton measurements: normalized frequency count analysis and seasonal dependency. *Journal of Photochemistry and Photobiology B: Biology.* 2005, 78, p. 149–154.

[23] VAN WIJK, R., SCHAMHART, D. H., Regulatory aspects of low intensity photon emission. *Experientia,* 1988, 44, p.586–594.

[24] SOLAR, P., TOTH, G., SMAJDA, B., AHLERS, I., AHLERSOVA, E. Circadian and circaannual oscillations of tissue lipoperoxides in rats. *Physiological Research*, 1995, 44, p. 249–256.

[25] BAYDAS, G., GURSU, M. F., YILMAZ, S., CANPOLAT, S., YASAR, A., CIKIM, G., CANATAN, H. Daily rhythm of glutathione peroxidase activity, lipid peroxidation and glutathione levels in tissues of pinealectomized rats. *Neuroscience Letters*, 2002, 323, p.195-198.

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