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Brie review

PHANTOM EARTHQUAKE SYNDROME - A PILOT STUDY AFTER ZAGREB AND BANOVINA 2020 EARTHQUAKE

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SUMMARY

Impact of earthquake on mental health is well-documented globally. A number of earthquake survivors after Zagreb and Banovina earthquake in the year 2020 reported a phenomenon of phantom earthquake. Telephone pilot study on phantom earthquake symptoms was conducted with semi-structured interview in earthquake survivors. Phantom earthquake is manifested as a false sense of earthquake-motion, accompanied with vegetative and motor symptoms with psychological distress and behavioral change that interfere with expected daily functioning. We propose an operational model for the phantom earthquake syndrome and discuss possible underlying neurobiological mechanisms to be further investigated in studying of the phantom earthquake syndrome.

Key words: *earthquake - distress - motion*

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INTRODUCTION

Earthquakes, being unpredictable in nature and causing substantial human and environmental damages, are strong traumatic events. Impact of earthquake on mental health has been well-documented globally with reports on high prevalence of post-traumatic stress disorder (PTSD), anxiety and mood disorders, and sleep disorders, which occur acutely and in years after the earthquake (Beaglehole et al. 2018, Farooqui et al. 2017).

Phantom earthquake, with no operational definetion, is described as a false sense of earthquake or aftershocks, that is not actually occurring, accompanied with number of dizziness-like symptoms and distress in earthquake survivors. It is, by some opinions, comparable to another motion syndrome, mal de debarquement syndrome (MdDS) ("sea legs"), which could be recurrent and bring distress in some cases (Mucci et al. 2020). Studies on earthquake survivors report on the other syndrome – earthquake sickness, with symptoms of dizziness and vertigo, which is related to vestibular or equilibrium disbalance during or briefly after the real earthquake or aftershocks take place (Miwa, 2021). To our knowledge, there has been no study of the phantom earthquake syndrome.

In 2020, Croatian capital Zagreb and nearby Banovina county (around 50 km from Zagreb), were hit with the series of earthquakes. Zagreb earthquake (March 2020, magnitude 5.5 Mw) and Banovina earthquake (December 2020, magnitude 6.4 Mw), were followed by series of aftershocks (ranging from 2 to 4 Mw). Both earthquakes caused great damages to facilities, houses, infrastructure and general environment and affected several thousands of people.

The role of mental health services has been widely recognized as crucial in elevating psychological consequences of earthquake in survivors (Farooqui et al. 2017). Center for crisis at the Department of Psychiatry and Psychological Medicine, Clinical Hospital Zagreb, with more than 30 years of experience in war and civilian crisis, responded promptly to the earthquake-crisis with reinforcement of telephone and online services for earthquake survivors and general population. Among common complaints like anxiety, panic, insomnia and changes in mood and behavior, clients spontaneously reported on the phantom earthquake which was accompanied with psychological distress and behavioral changes. We conducted a brief telephone study of the phantom earthquake symptoms.

SUBJECTS AND METHODS

Pilot-study enrolled clients who called telephone service for psychological support in post-earthquake period at the Center for crisis from October 2020 to January 2021. Inclusion criteria for participants were self-reported phantom earthquake by the caller and age from 18 to 65 years. Interviewer was not allowed to ask specifically for the phantom earthquake. Exclusion criterion was previously treated mental disorder (lifetime). Additional requirement was acquired usage of any earthquake registry. In semi-structured telephone interview, participants were asked to describe the symptoms, psychological distress, behavioral changes and duration of symptoms related to phantom earthquake. Calls were anonymous. Study was approved by institutional Ethics Committee as a part of a larger study.

Table 1. Model for phantom earthquake syndrome

no recorded earthquake by available earthquake registry/detection application
false sense of earthquake-like motion (ground shaking/trembling/vibrating; sense of moving/swinging objects)
motor and vegetative symptoms: vertigo, dizziness, nausea, motor instability, falling ("motion sickness-like" condition without motion)
psychological distress: anxiety, insomnia, panicking, worry about losing one's mind after false earthquake, confusion, preoccupation
behavioral change that interferes with expected functioning: intense startle response (trigger: any environmental noise), constant alertness to earthquake cues (checking earthquake detectors), changed daily routine (avoidance of inhouse activities).

Out of 500 of total calls, 23 participants (female= 15) were enrolled, mean age 49.5 years (range 22-64 years; sd±11,66), all with high school or university degree. Participants experienced either Zagreb or both earthquakes and report none, minimal and moderate household damages in 14, 8 and 1 case, respectfully. Qualitative analysis was applicable due to study design and sample size.

RESULTS

All participants spontaneously describe phantom earthquake phenomenon as a false sense of ground shaking/trembling/vibrating, endorsed by negative result on application for earthquake detection. Participants could not link the occurrence of false earthquake to any actual earthquake event and described it as a distinctive feature. 8 out of 23 participants reported awakening from night sleep with a false sense of earthquake, the others reported daily episodes. All episodes occurred inside housing facility. Sense of moving or swinging objects, like walls or furniture, was reported in 14 participants. Both motor and vegetative symptoms were reported by 12 participants, 2 of whom had fallen down. Psychological distress was described as prolonged anxiety, panicking, insomnia and preoccupation with earthquake registries. General concern was about losing one's mind when confronting the lack of earthquake detection at the time of episode. Participants reported an intense startle response to any environmental noise and high alertness on earthquake cues. Change in daily routine was reported by majority of participants, like avoidance of long or any inhouse activities that could be uncontrollable (like taking a shower or being on balcony) and engaging only in brief activities that could be promptly abandoned in the case of the next event. Duration of the phantom earthquake episode could not be determined, ranging from few seconds to minutes by participants' assessment. Frequency of the episodes was higher within the first week (1-5 times/week) after initial real earthquake and tend to diminish gradually within 1 to 3 months. Stress level was reported from moderate to severe with impact on functioning for 21 participants. Synthesis of reported symptoms makes a proposed operational model for the syndrome of phantom earthquake (Table 1).

DISCUSSION

An operational model for the phantom earthquake syndrome was synthesized after analysis of the phone interviews with the earthquake survivors (Table 1). Phantom earthquake, described as false sense of earthquake-like motion, is inevitably accompanied with motor and vegetative symptoms, substantial psychological distress and behavioral changes that interfere with expected daily functioning. To our knowledge, there has been no comparable studies on phantom earthquake syndrome.

Studies of earthquake sickness report symptoms fairly alike phantom earthquake, but related to actual earthquake or aftershocks and explained by neurological "mismatch" between the balance mechanism in the vestibular system of the inner ear and sensory signals (Miwa 2021). In our study, phantom earthquake symptoms occurred in earthquake survivors spontaneously without any relation to earthquake or aftershocks taking place at the time of the episode. Therefore, underlying physiological mechanism that would be responsible for false recognition of motion could not be correlated only to the equilibrium disbalance in inner ear as reaction to earthquake.

In absence of studies, some opinions refer to the comparison of the phantom earthquake symptoms with MdDS, which is a subjective perception of self-motion after exposure to passive motion (e.g. sway legs after sea travel). Notably, neuroimaging studies in MdDS show some structural, functional and metabolic brain changes in entorhinal cortex, amygdala and cortical regions that integrate visual, vestibular, and somatosensory input, that could be related to the chronic illusion of motion via functions of motion perception and spatial memory (Cha et al. 2012).

It should also be discussed if phantom earthquake could be regarded as a perception disorder, like illusion or hallucination. Studies on auditory and visual hallucinations report dysfunctional activation in regions typically associated with episodic memory retrieval and with reality- and self-monitoring that facilitate the generation of erroneous percepts evoked via interactions between past memories and abnormal activity in sensory brain areas (Zmigrod et al. 2016). There are no

similar studies on hallucinations or illusions with proprioceptive or kinesthetic features. Generally, information about body position and movement is not generated by single sensory perception but integration of various sensory inputs. Nevertheless, motor areas in the brain generate conscious sensations of body posture and movement even in the absence of sensory input. Perceptual organization involves process that is important to assigning salience to individual features of the sensory input to create a coherent unified perception of reality and integration is dependent on cognitive control mechanisms mediated by cortical brain structures (King et al. 2017). In what way traumatic experiences, like earthquake and possible effect of anxiety, could be related to altered brain function resulting in reoccurring false motion recognition, is not clear.

Psychological distress following phantom earthquake included preoccupation, anxiety and arousal, the symptoms that are similar and maybe overlapping with acute and post-traumatic stress disorder in earthquake survivors. Neuroimaging studies in PTSD report changes in function, structure and biochemistry of cortico-limbic networks (Harnett et al. 2020). Amygdala hyperactivity, reported in studies of anxiety and stress-related disorders, could be responsible for alteration in multisensory integration and protective mechanisms that would normally serve against distortions of self-perception and loss of behavioral control as amygdala is sensitive to novel multisensory input, which means it has access to information about previously experienced or expected sensory input (Spengler et al. 2019, Reader et al. 2019). Neuroimaging studies in earthquake survivors have also found anatomic and functional connectivity changes in frontal-limbic-striatal network (Lui et al. 2013, Jin et al. 2014, Du et al. 2015, Zhang et al. 2017, Bruno et al. 2021).

Functional interference due to phantom earthquake syndrome was recognized as significant burden for the earthquake survivors which gives additional consideration along with duration and treatment options.

CONCLUSION

Phantom earthquake, being false perception of earthquake-like motion, suggests underlying brain mechanisms that include sensory physiology, neural circuits involving cortico-limbic-striatal functions and integration of proprioceptive signals, memory and higher cognitive functions which could be affected by traumatic event and anxiety.

If the phantom earthquake could be a part of clinical presentation of acute or post-traumatic stress disorder in earthquake survivors or remains a specific syndrome, remains to be seen after further investigation. The neurobiological impact of severe anxiety on human ability to differentiate true and false stimulus has still to be elucidated.

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Contribution of individual authors:

Maja Bajs Janović: idea and design, conducting the study, analysis of results, interpretation of data, writing the manuscript.

Špiro Janović: idea and design, conducting the study results analysis, interpretation of data, writing the manuscript.

Maja Šeparović Lisak: conducting the study, data analysis, results analysis, data interpretation.

Sara Medved: conducting the study, literature search and analysis, results analysis.

Oliver Ojdanić: conducting the study, data analysis and interpretation, literature search and analysis.

Jurica Veronek: data analysis and interpretation, literature search and analysis.

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