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# Exploring Use of Wearable Sensors to Identify Early Symptoms of migraine Attack

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## **Abstract**

Migraine is a long-term failure mode including a risk of disease-related deficits that lead to social exclusion. The study was conducted among members of the Finnish Society for Migraine, and it aimed to determine and recognize the migraine patients with pre-symptoms and whether they would be willing to use wearable sensors in identifying pre-symptoms of migraine. The survey received responses from 565 persons, and more than 90 per cent of the respondents were willing to use the wearable sensors for the measurement of pre-symptoms, as well as to support the treatment. Moreover, the study revealed that 87.8 percent of migraine patients identified migraine early symptoms. The most common symptoms are tiredness, slow thinking, difficulty to find words and visual disturbances. Most of the respondents wanted the device placed on wrist as a watch, wristband or a skin patch.

## **Author Keywords**

Migraine; pre-symptoms; wearable sensors; health promotion

## **ACM Classification Keywords**

Sensor devices; Platforms; Wireless devices; Mobile; information processing systems; Sensor networks; Use cases; Data analytics

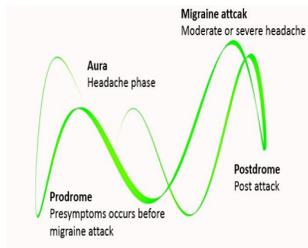


Figure 1: Migraine attack divided in four main areas.

**Prodrome:** Changes in mood, fatigue, yawning, muscle ache, feeling cold, swelling, food cravings, numbness of tongue, disturbances in memory, vision and hearing, aggressiveness

**Aura:** Temporary disturbance in cortex or brainstem with head ache. Lasts less than an hour. Head ache begins within less than an hour.

**Migraine attack:** Head ache phase lasts 4-72 hours. Pain is pulsating and one sided. Condition gets worse in physical stress. Associates to nausea, vomiting, sensitivity to light, noise and smells.

**Postdrôme:** Post attack symptoms may occur as tiredness, depression, restlessness, concentration problems, high energy

## Introduction

Migraine is a wide-ranging neurological disease, which is partly genetically determined. In Finland, 10 to 15 percent of the population suffer from migraines, and it forms one of the main health burdens in the country [15,2,7]. The current study explored if people suffering from migraine are interested in using wearable sensors to manage their migraine, and especially to identify the early symptoms of their migraine attacks. Migraine patients are classified as heavy users of health care services who need health care to treat migraine 7-17 times during the year. Medical studies show that health centers are burdened by heavy users and therefore the identification of migraine patients and health problems through the development system of the health care is important. Due to their hormonal changes women suffer from migraines far more than men. Migraine sufferers' measured peak is set from 25 to 44 years of age [1,2].

Migraine is divided into four phases: pre-symptoms of migraine, aura, migraine attack and postdrôme (see Figure 1). Studies show that migraine attacks are 4-72 hours in duration and are rapidly changing in shape. If a patient has 15 headache days in three months, the migraine is considered as chronic [8,9]. Pre-symptoms occur prior to the day of migraine attacks. Pre-symptoms are fatigue, yawning, increased appetite, sweet craving, irritability, and feeling cold. Headache aura or pre-symptoms usually last for 5-60 minutes and include light-sensitive eyes, sense of smell sensitization, visual field defects, sound sensitivity and numbness of face. Migraine can be treated with two types of medication: the preventive medication in daily use and acute medication after the detection of advancing symptoms.

The migraine treatments power depends on wherein the stage of the attack medication is taken. The best response to acute medication is gained when the drug can be taken prior to the headache phase [10].

In the future, health care is required to conduct more effective solutions in use because it seems that in Finland, Europe and the United States health is declining. Healthcare will face major challenges among working-age people whose work capacity is decreasing [11, 12,17]. The rapid development of health technology enables the availability of more efficient and better care, enabling people to remain fit for work for longer. Information and communication technology (ICT) allows a more sophisticated sensor technology for healthcare by providing data regarding the status of the individual and enables self-care by means of wearable sensors [3,6,17].

The sensors act as agents that modify the collected physical information to digital. Healthcare achieve a wide and comprehensive information via information received from the sensors. Electronic, thermostatic, optical, chemical and genetic signals can be used to monitor physiological, physical and cognitive health [4,6]. Medical sensors are integrated into the devices, systems, and environments, and their purpose is to sense the world [4,8]. Important measurable values for treatment are cardiogram, pulse, body temperature, blood pressure, oxygen saturation, as well as monitoring the daily activity. Sensor information is necessary for the assessment of the patient's condition, determining the correct diagnosis, and for making decisions on treatment and management of future plans [5,6,8].

	N	%
The light sensitive	100	18
The sensitive of smell	83	15
The deficiency of the face	24	4
The sensitive of voice	45	8
The fainting of the face	11	2
Bright light objects in the eyes	26	5
All combinations	276	49

Figure 2: Most common symptoms

### Research method and material

The current study was explorative in nature as at the time of the study there was only little knowledge available about the usage of body sensors in detecting migraine or its pre-symptoms in the use of the people suffering from migraine. [18].

A survey used as a means of collecting material was noted by [19], who valued it as an explicit category, and a research design, being different from other types of qualitative research. He listed four steps to conduct qualitative survey: defining knowledge aims, sampling, data collection, and analysis.

#### Data collection

The target group of the survey was consisted of was collected by email in September 2016. The questions were drawn up on the basis of a literature review, after which the Executive Director of the Finnish Society for Migraine and the employees assessed the comprehensiveness, suitability and comprehensiveness of the content. Based on the content evaluations, the query was edited to improve content's compatibility and comprehensibility, and four questions were deleted. After the quality inspection, the cover letter was clarified. In total, the questionnaire contained questions of background information and migraine pre-symptom related devices, totaling 7 questions. This study explored the need to identify the pre-symptoms of the study and the necessity of the device for treating migraine. The questionnaire included arguments to be valued, multiple choice questions, and write verbatim. In total, 565 responses were received. All questionnaires were properly completed, and no rejections were needed.

#### Analysis of data

The data were analyzed by classifying the research questions into two main categories, and using the SPSS 3.0 tools. The material was read through several times to obtain an overall picture and results were added to charts. Similarities were looked for from material, classes were reorganized and renamed in accordance with the content. Classes were condensed and combined based on query [16]. Percentages were used for description of material.

Background information of answers were classified by sex, type of migraine, migraine medication as well as the number of migraine attack. The material was analyzed by typical signs and symptoms associated with migraine headaches and they were classified as prodromal symptoms and major symptoms. The device issues were distributed, where the patients want a device to locate, what the device should measure and how many migraine patients would be willing to use wearable sensors to identify and treatment of migraine pre-symptoms.

### Findings and interpretation

The data were collected in September 2016 by sending an email inquiry to migraine patients who were members of the Finnish Society for Migraine, and all together 565 satisfactory filled questionnaires were received.

#### Questions about background information

The survey was responded by 534 (94.51 %) women and 31 (5.49 %) men. The difference between migraine without aura and with aura of the respondents was migraine without aura. Almost half (48%) of the respondents suffered at least five migraine attacks per month.

The number of monthly migraine attacks realizes in such sickness absence in which patients are classified as heavy users of health care. The study also asked if migraine respondents suffer eyes sensitive to light, sensitivity to sound, the sense of smell sensitization, numbness of the face, visual field defects, or blinking light in the eyes or combination of all the above-mentioned symptoms (see Table 2). According to the answers, 87.8 percent of the migraine patients recognized pre-symptoms of migraine. Among the most common symptoms were yawning, fatigue, slow thinking, difficulty finding words, and visual disturbances.

#### *Questions concerning the device*

The questions aimed to find out would the migraine patients be willing to use migraine symptoms sensing device. The answers revealed that 88.8% of the respondents would like to use a device, which can be used to predict the coming of migraine attack. The query was intended to identify on which part of the body the patients would like to use a wearable device and which measuring device was desirable. Moreover, the respondents were asked if they are willing to buy the device which detects coming migraine attack. Figure 3 shows that the majority of the respondents wanted the device to be located in wrist as a watch or as a wristband or a skin patch. The migraine patients felt it important that the device measures blood pressure, sleep quality, stress levels, pulse, and the intensity of pain. The majority of the respondents would buy the unit to improve the treatment of migraine according to the doctor's recommendations and evidence-based knowledge and it should work without charging for 3-7 days.

## **Discussion**

This study was a part of a project where it was studied if it is possible to detect the coming migraine attack by utilizing the intelligent systems or reading human bi-signals. Early intervention for the treatment of early symptoms of migraine can improve the quality of life of patients and the availability of preventative treatment as well as reduce sick leaves. The current study aimed to find an answer to the question if patients suffering from migraine are interested in using wearable sensors to manage their migraine, and especially to identify the early symptoms of their migraine attacks.

About half of respondents had migraines with aura and they were able to detect coming migraine easier and start to self-medicate before. Patients who experienced migraine without aura, experienced that the headache starts suddenly, but still suffered from migraine pre-symptoms which they didn't recognize as signs for a starting migraine attack. In the earlier study [13], it was shown that sleep quality is connected to migraine attacks, and insomnia is a major trigger of migraine, which also increases the body's stress hormone. Scientists [1] have measured the generation of migraine in previous studies, which have been studied by measuring the oxygen saturation of human biosignals, skin temperature, heart rate and activity. Sensing changes of human bio-signals allows to react to changing situations. Measuring and monitoring own health condition has gained popularity thanks to sensor technology and wireless data transfer [14]. The empirical study revealed that the patients are prepared to start monitoring their own health and the task of the health care could be to guide patients to observe the changing bi-signals.

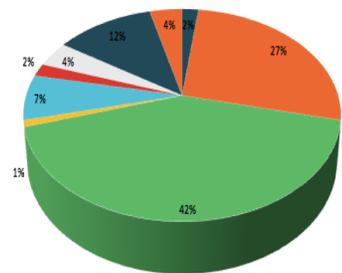


Figure 3: Desired locations for the device.

In order to avoid future long hospital care and long-term care we need intelligent systems to support self-care. In recent years, intelligent systems for health care have been raised as one of the most important research topics, and the monitoring and storage of their own health data are increasingly being used in health care. The purpose of intelligent systems is to make meaningful and objective pursuit of your health. With the results of the research, the systems are more Conclusions [17].

### Conclusions

In conclusion, the preliminary results are promising and indicate that migraine patients are willing to use intelligent systems to support migraine therapy and to identify them with pre-symptoms. By measuring pre-symptoms of migraine attack patients well-being and disease management can be promoted. Device measuring the pre-symptoms motivates monitoring of own health and support patients in self-care at home. At best, it will support patients in maintaining working capacity, as well as to promote physical, mental and social health. Identifying pre-migraine symptoms early enough, can reduce the high cost of health care burden of the user.

It should be noted, however, that the respondents represented a very large number of the plurality of migraine recipients in Finland. One can also assume that only those people responded who had difficulties or challenges in their migraine. It is possible that the willingness to receive advance information about the migraine attack is related to the potential biased nature of the respondents, and thus might have distorted the results.

There have been only few studies on the measurement of pre-symptoms of migraine, so given the diversity of studies, it is difficult to say how impressive method pre-symptoms measuring device is in support to migraine treatment. In the future, more studies are needed to evaluate the long term benefits of wearable sensors and the cost implications of support and management of the treatment of migraine pre-symptoms. Early intervention for the treatment of pre-symptoms of migraine can improve the quality of life of patients and the availability of preventative treatment as well as reduce sick leaves.

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