Skin AC conductance levels and responses in axillary hyperhidrosis patients

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***Abstract*— Six patients with varying degrees of axillary hyperhidrosis were examined using skin AC conductance (SC) and gravimetric measurements. The examination protocol included provocations of acoustic stimuli, arithmetic tasks and physical activity while the SC was recorded. A significant correlation (R^2=0,69, p<0,05) was found between the gravimetric measurements and the baseline SC, but not with the responses (R^2<0,36, p>0.05), suggesting that the responses bring additional physiological or psychosomatic information which may be useful to the diagnosis or treatment evaluation of the disease.**

Keywords— **Skin conductance, sweat, parameterization, EDR, hyperhidrosis**

I. INTRODUCTION

The condition hyperhidrosis, which is associated with excessive sweating, is often difficult to evaluate objectively [1]. The severity of the disease can vary over a wide range among the patients, and it is not known how big the overlap is in the extent of sweating between those who consider themselves normal in this regard and that of the patients. The correct diagnosis of this condition is especially important due to the radical treatment procedures such as injection of nerve toxin or irreversibly cutting nerves that lead to the affected area. These procedures are not without risks or side effects [2], and misdiagnosed patients should not undergo them.

One challenge with the diagnosis of hyperhidrosis is the appearance of the symptoms, which may be highly dependent on certain triggers, time of day/month or other external factors [3]. These triggers may be stressful events or physical exercise [3]. A thorough evaluation of the patient should include these considerations. Hence, self-assessment of the severity of the sweating on an hourly basis throughout the day has been used successfully for the evaluation of the condition [3].

Skin AC conductance (SC) has been proposed as a method of measuring sweat activity (SA) [4, 5]. The aim of the present study was to investigate the usefulness of this method as an assisting clinical tool in the evaluation of axillary hyperhidrosis. To study the SA during different circumstances, a protocol was designed which included three different stimuli. First, an acoustic stimulus which is meant to trigger a sudden activation of the sympathetic nervous system resulting in an electrodermal response (EDR) [6]. Second, an arithmetic stimulus over a given time period provoking a continuous stressful situation [7], and third, a short stimulus of physical activity. These stimuli should account for the most common SA triggering events in the patients, and could be performed within the 30 minutes of examination time that was given.

II. MATERIALS AND METHODS

A. Patients and equipment

Six patients with complaints of axillary hyperhidrosis, all female between the ages of 19-42 were chosen for the study and gave informed consent. They had all shaved their armpits two days in advance of the study. The patients were wearing relatively similar clothing of long trousers and outdoor shoes on the lower body, and a bra on the upper body while the temperature in the room was kept constant at approximately 22ºC to reduce influence from environmental temperature effects on the measurements. During the measurements, the patients were lying on their backs with the arms resting behind the head exposing the armpits. Sweat production volume was measured in both axillae by placing absorptive paper on the armpit skin surface and sealed with plastic wrap to avoid evaporation. The paper was attached for 5 minutes, and the weight increase was measured with a Mettler Toledo AT200 precision weight. A BioGauge Sudologger [4] was used for multichannel unipolar SC measurements After the gravimetric measurement, Sudologger electrodes were placed at the apex of both axillae, the hypothenar area of the right palm and on the abdomen.. The hypothenar area was selected as a reference for sympathetic activity, and the abdomen as a reference for thermoregulato-

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ry SA. None of these areas were covered with clothing during the measurements.

B. Protocol

The SC measurement session was part of a larger study at Rikshospitalet University Hospital with the aim of comparing two different surgical procedures for treating axillary hyperhidrosis. These measurements were done at the initial phase of this study, four days before the surgery. In order to keep the test situation similar for this experiment and the follow-up experiments in the future, the patients were informed in detail about the provocations in the protocol. The protocol was a total of 30 minutes consisting of:

1. Seven minutes of relaxation
2. Instantaneous acoustic stimulus
3. Seven minutes of relaxation
4. Two minutes of arithmetic task
5. Seven minutes of relaxation
6. Instantaneous physical activity
7. Seven minutes of relaxation

The duration of seven minutes selected for the relaxation periods was based on stimulus measurement data from [5], where the average 95% recovery period with one standard deviation added equaled approximately seven minutes. The acoustic stimulus was given as a 2,5s sound sample of a breaking glass by a set of speakers played at an intensity measured to be 82dB 1 meter in front of the speaker. The speakers had a fixed position and the patients heads were resting at an equal position directly above them. None of the patients were known to have impaired hearing, thus each patient received a comparable stimulus from the speakers. The arithmetic stimuli were a series of subtraction tasks. The patient was told to start with the number 1000 and consecutively subtract numbers given by the operator. These numbers were not predetermined, but were tuned by the operator in order to give each subject a similar challenge which started easy and increased in difficulty over the two minutes. The physical activity consisted of raising the upper body as far as possible and lowering it again immediately while lying on the bed and trying not to move the arms.

C. Measurement parameters

In order to objectively evaluate the reaction to the different events, the following parameters were extracted from the SC time-series. If there were differences in the measurements from the left and right axillae, the average was used for the parameter calculations.

1. Baseline: The stable SC level which is reached during the relaxation periods.
2. Response to acoustic stimulus: The amplitude of the SC response following the acoustic stimulus.
3. Response to arithmetic stimulus: The maximum SC measurement within the arithmetic stimulus interval subtracted by the prestimulus level.
4. Response to physical activity: The amplitude of the SC response following the physical activity.

The gravimetric measurements were used for comparison with these parameters.

III. Results

Table 1 shows the parameters extracted from the SC measurements at the axillae and the gravimetric measurement for each patient. Table 2 shows the R^2 correlations between the parameters.

Table 1 SC parameters and gravimetric measurements

Patient	Baseline	Acoustic	Arithmetic	Physical	Gravimetric
1	2,5	0,7	0,5	0,3	6,8
2	7,5	0,4	3,0	0,3	18,7
3	8,0	0,0	5,0	1,0	38,2
4	7,0	2,0	3,0	3,1	103,3
5	11,0	3,0	9,0	4,3	35,7
6	21,0	2,5	7,0	3,4	177,8
Unit	μS/cm^2	μS/cm^2	μS/cm^2	μS/cm^2	mg/5min

Table 2 R^2 between the parameters. *Significant correlation ($p<0.05$)

R^2	Acoustic	Arithmetic	Physical	Gravimetric
Baseline	0,34	0,52	0,38	0,69*
Acoustic		0,45	0,89*	0,31
Arithmetic			0,61*	0,15
Physical				0,36

IV. Discussion

The SA measurement protocol yields new parameters which may or may not be a useful addition to the diagnosis of axillary hyperhidrosis. Whether these parameters are independent or not is a subject for discussion. As table 2 suggests, some of these parameters may be related. The gravimetric measurement can be used as a reference parameter for the SC measurements, but only for the baseline since this parameter and the gravimetric measurement both represent relaxation levels and not responses. There is a significant correlation between the gravimetric measurement and the baseline SC measurement, but not with the responses. This suggests that the response parameters may yield additional information of diagnostic value beyond the gravimetric measurement. Table 2 also shows the unexpected strong correlation between the physical and acoustic response although the sources of triggering are very different. There is also a significant correlation between the physical and arithmetic response. This suggests that perhaps only one or two of the provocations would have been sufficient for the evaluation of these patients in addition to the baseline or gravimetric measurement. However, the number of measurements is too low to make any conclusions on this in general with regard to false negatives.

There is a relatively large variation between the patients among all the parameters including the gravimetric measurement. These patients have not previously been evaluated quantitatively, and they are in the patient category largely based on their subjective symptomatic complaints. Patient 1 differs significantly from the others in both baseline, arithmetic stimulus and the gravimetric measurement which may suggest that this patient did not belong in the patient group. According to the medical examiner of these patients, patient 1 was suspected to be asymptomatic while patient 6 was suspected to have the most severe symptoms among the patients. This is in agreement with the baseline SC parameter. In order to evaluate the diagnostic value of the parameters, more measurements need to be done on both patients and controls for a thorough statistical analysis.

Many aspects of this disease is still not completely understood, and there may be different types of the condition where some patients are triggered by certain events while others are having a constantly elevated baseline. The former may be psychosomatic, while the latter may be a physiological abnormality of the sweat glands or their functioning or abnormalities in the central nervous system. These are both examples of hyperhidrosis, but may require completely different treatment approaches. Thus, the examination should include methods to distinguish between these categories of the disease.

V. Conclusion

The introduction of new independent SA parameters yields additional physiological or psychosomatic information which may be helpful to the diagnosis or treatment evaluation of hyperhidrosis. Due to the physiological variations among the different categories of the disease, more subjects including controls should be tested to evaluate the usefulness of the parameters. This can help the clinicians in designing an optimal protocol for the objective evaluation of the patients.

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