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Technical report

Electrochemical skin conductance for quantitative assessment of sweat function: Normative values in children

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ABSTRACT

Objectives: The Sudoscan™ system (Impeto Medical, Paris, France) has been recently proposed as a standardized, easy, painless tool for sudomotor function assessment. It is now used as an additional diagnostic tool in small fibre neuropathy. So far, no work has been published in children. The aim of this study was to measure electrochemical skin conductance (ESC) using the Sudoscan™ system in children in order to assess its feasibility and to provide normative values.

Methods: 100 children were included in the study: 55 girls and 45 boys, age rank 2–17, mean 10.5 y. They were accompanying their brother or sister who came as outclinic patients in the Department of Paediatrics or the Department of Paediatric surgery of the University Hospital.

Results: All subjects underwent the test. It was performed without any difficulty, except for some of the youngest who sometimes had some trouble in keeping calm for 3 min over the plates. 4 subjects who took the test were excluded from the analysis (2 diabetic patients and 2 having had previous chemotherapy). ESC was quite stable along childhood with an overall 80.1 μS value for hands and 81.9 μS for feet, very similar to what is observed in adults.

Conclusion: Maturation process seems to occur early in life, in accordance to sudomotor control when assessed by sympathetic skin response, which is also recorded early in infancy.

Significance: ESC measurement is a simple and easy-to-perform test that can be performed in the clinical setting in children in 5 min.

1. Introduction

Sympathetic nerve fibres innervating sweat glands are long, thin and unmyelinated C-fibres. They can be damaged very early in various disease processes and assessment of sweat function has been proposed as a tool to explore peripheral dysautonomia. Currently, sudomotor function can be evaluated via Quantitative Sudomotor Axon Reflex Testing (QSART), Thermoregulatory Sweat Testing (TST), the Sympathetic Skin Response (SSR) or skin biopsy. However, these tests remain underutilized, especially in the paediatric population, due to the specialisation required, the time needed for the test or their invasive character. The Sudoscan™ system (Impeto Medical, Paris, France) has been recently proposed as a standardized, easy, painless tool for sudomotor function assessment through measurement of electrochemical skin conductance (ESC). In contrast to SSR, it directly evaluates sweat gland function: the device uses direct current stimulation with very low intensity and reverse iontophoresis to measure the local conductance derived from the electrochemical reaction between sweat chloride ions and the nickel included in the stainless steel electrodes in contact with the palms of the hands and soles of the feet (Bordier et al., 2016; Vinik et al., 2016). To date, no research on using this method in children has been published. The aim of this study was to perform ESC measurement in children in order to test the method's feasibility in paediatric age groups and to provide normative values for ESC.

2. Methods and subjects

Subjects were healthy children accompanying their brother or sister who came as outpatients in the Department of Paediatrics

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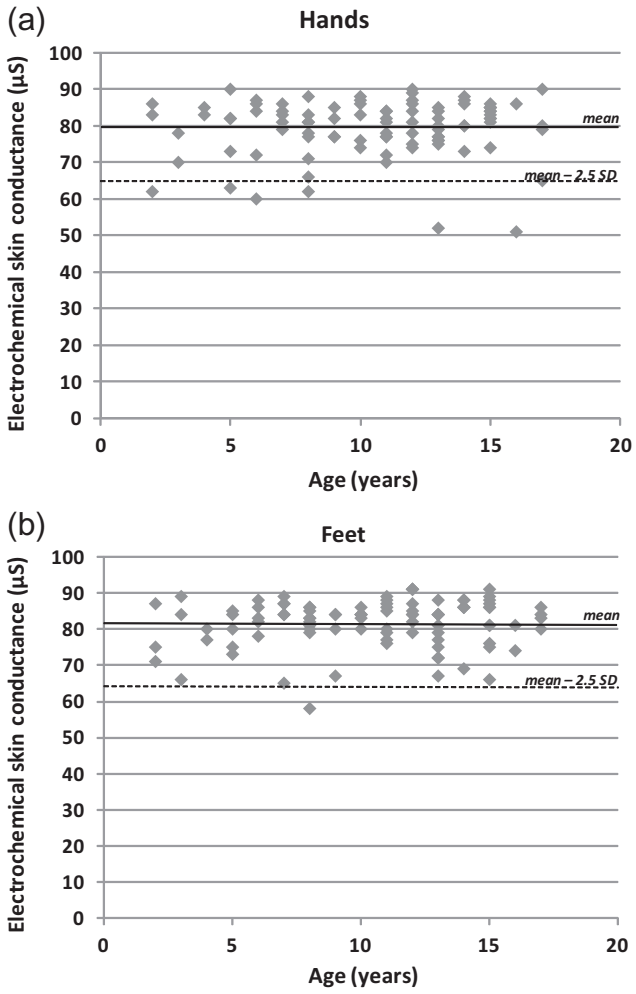

Fig. 1. Individual hand (a) and foot (b) conductance values in microSiemens (µS) according to age (years). Mean values and mean – 2.5 SD values are provided.

or the Department of Paediatric surgery in the hospital. Parents were systematically asked about specific neuromuscular diseases (familial or not), metabolic or general disease, and actual and past treatments. The subjects underwent ESC testing using the Sudoscan system after informed consent was obtained from themselves and/or from their parents. Briefly, they had to stay for three minutes with bare hands and feet placed on specific plates from the Sudoscan system for the recording. The study was approved by the local ethic committee. 100 children were included in the study: 55 girls and 45 boys, age range 2–17, mean 10.5 years. Female teens were not asked regarding menstrual cycles. All the children were at rest after having been waiting for at least 15 min in the waiting room of the Paediatric department at constant temperature (22 °C). No other specific measure was undertaken.

3. Results

3.1. Normative data

All subjects underwent the test without any difficulty, except for some of the youngest who sometimes had difficulty remaining still on the plates for the 3 min of testing. 4 subjects completed the test but were excluded from the analysis (2 had diabetes and 2 had previously received chemotherapy). Electrochemical skin conductance was quite stable along childhood. Fig. 1 displays the raw data for both hand and foot ESC. Test of normality (Shapiro-Wilk test) was negative for both hands and feet. There was no correlation between hand or foot ESC and age (Spearman correlation). There was no significant difference between male and female subjects (Mann-Whitney U test). ESC (mean ± SD) was 80.1 ± 6.6 µS in hands and 81.9 ± 6.2 µS in feet. Left-right asymmetry (mean ± SD) was 3.0 ± 3.5% for hands and 2.4 ± 3.9% for feet.

3.2. Discussion

ESC measurements performed in 100 children confirm that this method can be used in the paediatric population. Values observed for ESC measurements in these healthy children are similar in all four groups of age and comparable to values observed in healthy adults (Vinik et al., 2016). A good symmetry is also observed between right and left sides for hands and feet in accordance with results among adults.

Our findings suggest that sudomotor nerve maturation occurs early in life, in accordance with earlier studies showing SSR recorded early in infancy. ESC values depend on sweat gland density, which is equivalent in infants and adults, explaining why ESC values observed in children are comparable to adult values. ESC has been evaluated against usual methods recommended to assess small fibre neuropathies including laser evoked potentials, quantitative sensory testing with determination of warm and cold thresholds and SSR (Lefaucheur et al., 2015). Sensitivity of ESC measurement to detect dysautonomia in adults has been evaluated in several diseases including diabetic peripheral neuropathy as compared to Neuropathy Impairment Score of the Lower Limbs, vibration and cold detection threshold, and transthyretin familial amyloid polyneuropathy (Selvarajah et al., 2015; Castro et al., 2016).

One important limitation of the study is that the healthy status of the children especially with regards to peripheral nerves was not confirmed by other tests mainly due to the fact that these tests are difficult to perform in children. Another limitation is that only one measurement per subject was performed; however, the method's accuracy has already been evaluated in adults and was not the aim of this study. Further work in children with e.g. diabetes mellitus or toxic neuropathy (Vinscristine) comparing ESC measurement and other techniques such as sympathetic skin responses could be considered in order to help defining the actual interest of ESC measurement.

4. Conclusion

ESC measurement is easy to perform in young patients and could be used to assess and monitor dysautonomia in children as long as they are able to stand on the plates without moving during the 3-min time duration of recording.

Conflict of interest

None for all authors.

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