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Brief Report

Inclusion of Height and Limb Length when Interpreting Sympathetic Skin Response

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Abstract

It is more than a decade since scientists are making use of sympathetic skin response (SSR) as a clinical and research method to evaluate sympathetic nervous system. A major portion of the efferent pathway of this response is composed of non-myelinated nerves. Thus, the latency of the response may be significantly different in normal individuals with different height and limb lengths. This study was designed to investigate the effect of these parameters on the SSR results.

We measured the height and limb length of 65 normal individuals with different heights (divided into 3 groups of height ≤150 cm, 150-170 cm, and ≥170 cm). The participants had neither peripheral nor central neuropathy. They also had none of the exclusion criteria. Then, they underwent SSR testing of both palms and soles. The correlation between the height and limb length in relation to SSR parameters (latency and amplitude) was analyzed statistically by Pearson's correlation.

No significant correlation was detected between the height and limb length and the SSR amplitude. However, the results showed significant correlation between SSR latency recorded from all four sites (both palms and soles) and the height of participants. Furthermore, there was a significant correlation between SSR latency recorded from any limb and the length of that limb.

Regarding the significant effect of the height and limb length on the SSR latency, both the height and limb length should be considered when interpreting the results of SSR.

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Keywords ● Sympathetic nervous system ● Limb length ● Height ● Sympathetic skin response

What's Known

- Sympathetic skin response (SSR) latency may be significantly different in normal individuals with different height and limb length.

What's New

- Significant correlation between SSR latency recorded from four sites (both palms and both soles) and the height of individuals.
- Significant correlation between SSR latency recorded from any limb and the latency of that limb.

Introduction

Autonomic nervous system is a complex structure with tremendous effects on almost all organs and systems in the body. Diagnosis of disorders of this important part of the nervous system is a challenge to physicians. There are several ways to evaluate autonomic nervous system clinically and paraclinically. One way to assess the disorders of the sympathetic system is sympathetic skin response (SSR), which is a result of polysynaptic reflex arch activation.[1] Despite several studies, the exact central pathways of this reflex is not yet well defined.[2-4] It is proposed that the efferent part of the SSR arch consists of the myelinated preganglionic and non-myelinated postganglionic C fibers.[1]

It is more than a decade since scientists are making use of SSR as a clinical and research method to evaluate sympathetic

nervous system. It has been used to detect sympathetic nervous system derangement in a wide spectrum of diseases such as central and peripheral neuropathies, rheumatologic problems, spinal cord injury, Crohn's disease, and even in burn.[5-8] Additionally, it may have the potential to predict autonomic derangement symptoms before their occurrence in some circumstances.[9]

Any paraclinical and electrodiagnostic test has its own methodical and interpretational limits; and SSR is not an exception. Latency and amplitude of the response are the two important parameters used for result interpretation. Both parameters are dependent on the distance from the stimulator. Since a major portion of the efferent pathway of the response is composed of non-myelinated nerves, the latency of the response may be significantly different in normal individuals with different height and limb length.

To the best of our knowledge, no study has reported investigation on the effect of height and limb length on the latency and amplitude of the SSR. Therefore, this study was designed to investigate the effect of these parameters on the two important aspects of SSR and to help a better interpretation of the test results.

Materials and Methods

Sixty-seven patients who referred to the Physical Medicine and Rehabilitation Clinics of Shiraz University of Medical Sciences were recruited. Among these, 16 were with the height of 150 cm or less, 31 with the height between 150 and 170 cm, and 20 with the height of 170 cm or more. All patients had a negative history of peripheral/central neuropathy, diabetes mellitus, and none used any drug affecting autonomic nervous system. To ensure that no peripheral neuropathy will confound the results, all participants underwent nerve conduction study. Among these, two individuals failed to show normal values and thus excluded. The other 65 individuals underwent SSR testing of both palms and soles. Written informed consent was obtained from all participants.

SSR was taken in a quiet room with the temperature of 24ºC. Participants laid supine with the eyes open so that they do not fall asleep. They were also requested not to sigh, laugh, cough, or breathe deeply during the study. The settings of the Synergy multi-linker EMG machine were as follows: 0.5-2 KHz band pass, 500 ms/div base time, 100-200 mV/div amplification, and 20-45 mA intensity.

Active recording electrodes were placed on the palm of each hand, plantar surface of each foot, and the reference electrodes were placed on the dorsum of the hands and feet, respectively (Figures 1 and 2).

We stimulated the median nerve at the wrist (8 cm from the mid palm, where the recorder was placed) and tibial nerve posterior to the medial malleolus (10 cm from the midsole, where the recorder was placed). The cathode was orientated proximally. The ground electrodes were placed around the forearm and the leg, respectively. Thirteen stimuli were administered at random intervals of more than 30 seconds to avoid habituation for each stimulation site. SSR latencies were measured from the origin of the trace to its first deflection from baseline.

For each recording site (palms and soles) mean latency of 12 consecutive responses, excluding the first, were measured separately. We used manual averaging rather than automatic average to avoid possible phase cancellation. Stimulations that resulted in no detectable deflection were excluded from the averaging process. The average of the peak-to-peak amplitudes was calculated in the same manner for each recording site.

We measured the height of the participants from the ground to the uppermost point on the scalp while they were standing erect in front of a wall. The upper limb length was measured as the

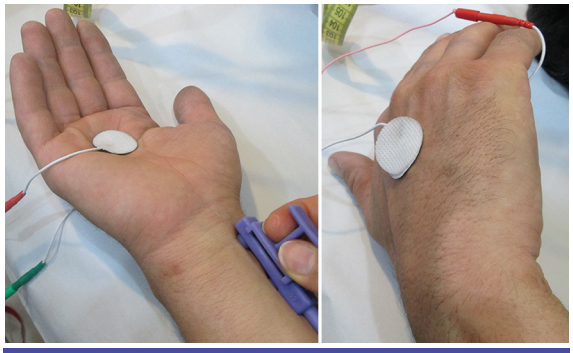

Figure 1: Shows sites of the recording (active: the left picture, reference: the right picture) and stimulating electrodes for detecting SSR from the palm.

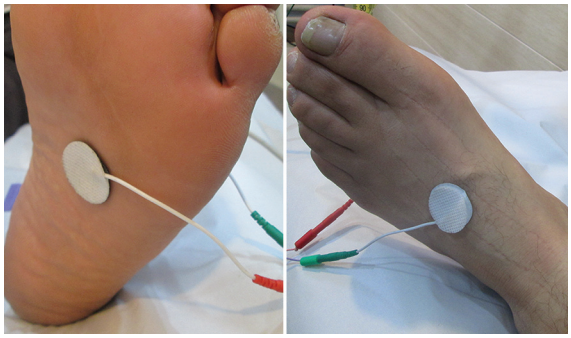

Figure 2: Shows sites of the recording (active: the left picture, reference: the right picture) and stimulating electrodes for detecting SSR from the sole.

distance from the tip of the shoulder (acromion process) to the mid palm, just proximal to the distal crease at the third intermetacarpal space. The lower limb length in this study was defined and measured as the distance from the anterior superior iliac spine to the midsole (midway between the second metatarsal head and calcaneal tuberosity at the second intermetatarsal space).

The correlation between the height and limb length and the SSR parameters (latency and amplitude) was analyzed statistically by Pearson's correlation.

Results

The mean values of SSR amplitude and latency of all recording sites are presented in Table 1. No difference was detected between the two sides of the body in terms of SSR latency or amplitude. The mean values of the height and limb length of the participants are presented in Table 2. Table 3 shows the correlation between the height and limb length and the SSR amplitude and latency. As shown in the table, no significant correlation was detected between the height and limb length and SSR amplitude. However, the results showed significant correlation between SSR latency recorded from all four sites (both palms and both soles) and the height of participants. Furthermore, there was a significant correlation between SSR latency recorded from any limb and the length of that limb (P<0.001).

Table 4 summarizes the mean SSR latency and amplitude of the four recording sites in different height groups (≤150 cm, 150-170 cm, and ≥170 cm). Comparison between groups shows that group 3 (≥170 cm) was significantly different from the other two groups in terms of SSR latency (P<0.001). Groups 1 and 2 were not significantly different from each other in terms of SSR latency. Regarding SSR amplitude, no significant difference was detected between the groups except for the right and left palm, which were significantly different in group 3 compared with group 2 (P=0.018 and P=0.014, respectively).

Table 1: Mean and standard deviation of SSR results

Indices	Mean±SD
Right palm amplitude	623.84±105.36
Left palm amplitude	625.23±103.99
Right sole amplitude	558.46±104.42
Left sole amplitude	559.23±106.76
Right palm latency	1.31±0.34
Left palm latency	1.31±0.34
Right sole latency	1.52±0.36
Left sole latency	1.52±0.36

Table 2: Mean and standard deviation of the height and limb lengths

Indices	Mean±SD
Height	164.18±10.52
Right upper limb length	65.33±2.44
Left upper limb length	2.44±2.47
Right lower limb length	104.42±4.07
Left lower limb length	104.42±4.07

Discussion

Similar to other studies,[1,10,11] the results of our study showed no difference between either side of the body in terms of SSR latency and amplitude. As shown by previous studies, the SSR latencies recorded from the soles were more prolonged compared with those recorded from the palms.

Several studies have been conducted to shed light on the neurologic pathways responsible for sympathetic skin response.[2,12] It is generally believed to be a polysynaptic reflex generated in the deep layers of the skin by activation of sweat glands via sudomotor sympathetic efferent fibers.[13] Despite the interest of many researchers in clarifying the pathways and different aspects of SSR, we found no articles on why the latency of the responses recorded from the soles is more prolonged than that of the palms and its significance when interpreting a test. This difference may be due to a longer distance the efferent pathways of SSR have to travel for the sole recording site than for the palm. These efferent pathways are mainly made up of unmyelinated C type nerve fibers with slow conduction velocity. Therefore, any increase in the distance may have a significant effect on the latency and amplitude of the recorded waves. Some studies have pointed to the possible effect of the height on the results of SSR, however, it remains controversial.[12,14,15] We found no reported investigation on the effect of the limb length on the SSR results.

Considering the growing application of SSR in detecting the autonomic system derangements, even before clinical symptoms are present,[5-9] one should pay more attention to the interpretation of a test (i.e. is it in normal range for an individual patient, or of pathologically prolonged latency, or reduced amplitude). According to the results of this study, the height and limb length are significantly correlated with SSR latency. A comparison between the three height groups showed that although SSR latency was more prolonged in group 2 than group 1, but such difference was

Table 3: Significance of correlation between SSR results and height and limb length

Indices	Height	Right-upper length	Left-upper length	Right-lower length	Left-lower length
Right palm amplitude	P=0.603	0.393			
Right palm latency	0.000	0.000			
Left palm amplitude	P=0.710		0.379		
Left palm latency	0.000		0.000		
Right sole amplitude	P=0.536			0.531	
Right sole latency	0.000			0.000	
Left sole amplitude	0.463				0.476
Left sole latency	0.000				0.000

P: Pre-value

Table 4: Comparison of SSR latency and amplitude between height groups

Height groups	Right palm amplitude	Left palm amplitude	Right sole amplitude	Left sole amplitude	Right palm latency	Left palm latency	Right sole latency	Left sole latency
1								
2	P=0.702	P=0.604	P=0.393	P=0.452	P=0.915	P=0.915	P=0.741	P=0.753
3	P=0.147	P=0.159	P=0.405	P=0.521	P<0.001	P<0.001	P<0.001	P<0.001
2								
1	P=0.702	P=0.604	P=0.393	P=0.452	P=0.915	P=0.915	P=0.741	P=0.753
3	P=0.018	P=0.014	P=0.953	P=0.942	P<0.001	P<0.001	P<0.001	P<0.001
3								
1	P=0.147	P=0.159	P=0.405	P=0.521	P<0.001	P<0.001	P<0.001	P<0.001
2	P=0.018	P=0.014	P=0.953	P=0.942	P<0.001	P<0.001	P<0.001	P<0.001

P: Pre-value

insignificant. Nonetheless, looking at group 3, this parameter becomes significantly more prolonged compared with the previous groups. This should alert us that the increasing height, particularly when it passes a threshold point (e.g. 170 cm), could significantly affect SSR latency and should be taken into account when interpreting the latency.

The results of this study indicate that the height and limb length have no effect on SSR amplitude. Although the palm SSR amplitude was significantly different in group 3 (height ≥170 cm) compared with group 2, it has no clinical meaning since such difference was not found between group 3 and 1.

Latency prolongation and reduced amplitude of SSR has been considered as criteria for its abnormality.[5] Considering the rising interest by scientists to utilize SSR as a simple, inexpensive method for the evaluation of autonomic nervous system, it is necessary to differentiate between normal and abnormal SSR latency values. Furthermore, since unmyelinated nerve fibers compose a major portion of the SSR pathway, as shown by the present study, larger distance due to increased height or limb length can significantly change SSR latency in normal population. Therefore, prior to interpreting SSR results, one should measure and take into account the height and limb length of that person.

More studies with larger sample size may lead to the development of a formula that relates the height and limb length to SSR latency. Such equation would assist physicians to interpret SSR test results accurately in clinical settings.

Conclusion

Considering the significant effect of height and limb length on SSR latency, both the height and limb length should be considered when interpreting the results of SSR. This would prevent misinterpretation of a normal SSR latency in tall patients with a longer limb length.

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Conflict of interest: None declared.

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