Comparing cardiac and skin sympathetic nervous system activity

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Short Abstract

The Vrije Universiteit Ambulatory monitoring system can in principle measure the pre-ejection period (PEP) from the impedance cardiogram and skin conductance level (SCL) form two palmar electrodes in ambulatory real life settings. To test whether PEP and SCL quantify sympathetic nervous system (SNS) activity in a comparable way data were first obtained under standardized lab conditions from 39 human subjects during exposure to 13 different experimental conditions. Compared to pre-test resting baseline recordings significant decreases in PEP and parallel increases in the SCL were found for various stressors known to increase SNS activity. The between and within subjects correlations between PEP and SCL were not significant. This suggests that SNS activity is reflected differently by the heart and the skin. We conclude that SNS activity studies, when possible, should include both PEP and SCL measurement.

Introduction

The Vrije Universiteit Ambulatory Monitoring System (VU-AMS) can measure the pre-ejection period (PEP) from the impedance cardiogram and skin conductance level (SCL) from two palmar electrodes in ambulatory real life settings. In principle this would allow us to measure sympathetic nervous system (SNS) activity from two entirely different organ systems. Under the assumption that SNS activity to most mental and physical stressors presents a unitary response, this dual read-out of PEP and SCL would provide us with a convergent and robust estimation of SNS activity. However it has been questioned whether SNS activity indeed presents itself as a unitary response across multiple organ systems. In this study we investigated the extent to which Pre-Ejection Period (PEP) and Skin Conductance Level (SCL) responses are correlated, and whether they can be considered to measure SNS activity in a comparable way.

Methods

Physiological data were obtained from 38 human subjects (23 males) during 8 different mental or physical stressors and 5 resting/recovery periods. The ECG and ICG were recorded using seven pregelled Ag/AgCl spot electrodes (UltraTrace, ConMed, USA) in the typical VU-AMS configuration shown in Figure 1. The electrodes were connected to the ECG100C and NICO100C BioPac modules using extension leads.

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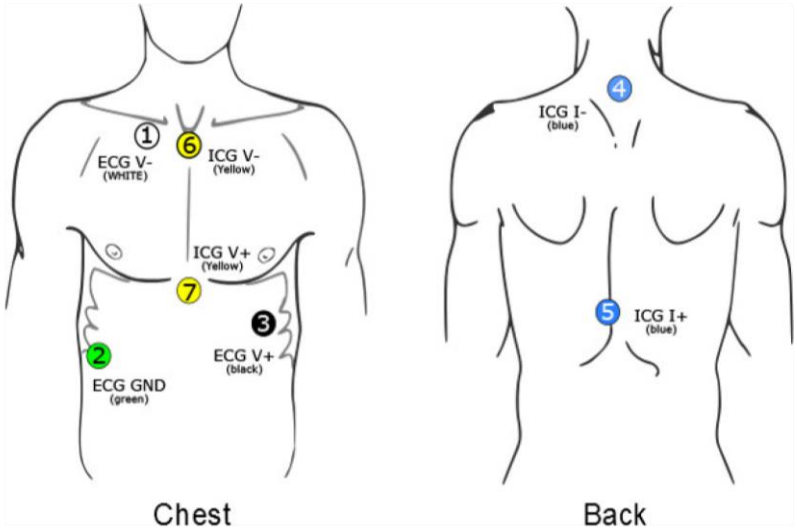

Figure 1. The seven electrodes should be placed on the participant's chest and back. The first ECG electrode (V-) is placed slightly below the right collar bone 4 cm to the right of the sternum. The second ECG electrode (V+) is placed at the apex of the heart over the ninth rib on the left lateral margin of the chest approximately at the level of the processus xiphodius. The third ECG electrode (GND) is a ground electrode and is placed on the right side, between the lower two ribs at the right abdomen. The first ICG measuring electrode (V_1) is placed at the top end of the sternum, between the tips of the collar bones. The second ICG measuring electrode is placed at the xiphoid complex of the sternum, where the ribs meet. The two current electrodes are placed on the back: I- on the spine over the cervical vertebra C4, at least 3 cm (1 in) above the ICG measuring elec-trode V-, and I+ between thoracic vertebrae T8 and T9 on the spine, at least 3 cm (1") below the ICG measuring elec-trode V_2. The ICG electrode placement takes into account that the largest part of the left ventricle driven change in thorax impedance is captured by the column between the suprasternal notch and the processus xiphoideus.

Skin Conductance information was collected using a pair of Ag/AgCl (unpolarizable) electrodes (Ø = 6 mm) attached with a Velcro strap to the distal phalanx of the index and middle finger of the non-dominant hand. To ensure sufficient electrode–skin contact, isotonic electrode paste was used (0.5% saline in a neutral base). The electrodes were connected to the GSR100C BioPac module.

The various experimental conditions were explained to the subject and the mental and physical stress tasks were briefly practiced. The actual experiment started by asking the subjects to sit quietly and relax for a pre-test 10 minutes resting baseline. Next, the following conditions were presented in a fixed order: Stroop colour word task (4 min), recovery1 (3 min), tone avoidance task (4 min), recovery2 (3 min), lying (2 min), standing (2 min), recovery3 (2 min), hand grip test (2 min), cold pressure test (1 min), recovery4 (3 min), and the step test (2 min). After the step test a final post-stress resting condition of 13 minutes concluded the physiological recordings.

Pearson correlations were computed between PEP and SCL separately for each of the conditions (between-subject correlations) and separately for each of the subjects across all conditions (within-subject correlations).

Results

Between-subject correlations show PEP to be largely uncorrelated with SCL. Within-subject correlations across the 13 experimental conditions are shown in Table 3 (modified from Goedhart AD, Willemsen G, De Geus EJC (2008). *Sympathetic nervous system activity in the heart and the skin: are they comparable?* In M. Kaneko (Ed.), Sympathetic Nervous System Research Developments. New York: Nova Science Publishers. pp93-114). The mean within-subject correlation between PEP and SCL was -.43, but large individual differences were found. Furthermore, inspection of the scatter plots strongly suggested that the relation between PEP and SCL

entirely depended on the exercise condition. When we recomputed the within-subject correlations after exclusion of the step test data, the correlation between PEP and SCL remained significant in one subject only.

Conclusion

We show that PEP and skin conductance respond to stress tasks in a manner compatible with increased SNS activity but that within the same subject their response is largely uncorrelated. The heart and the skin, therefore, seem to reflect different aspects of SNS activity. Since both measures have already shown their usefulness in biomedical and psychophysiological research, PEP and SCL should ideally be measured in parallel.

Table 3 Within-subject correlations between PEP and SCL for all conditions, and for all all conditions except the steptest.

	All conditions		*All conditions except the step test condition*	
Subject	$r_{PEP\text{-}SCL}$	*p*	$r_{PEP\text{-}SCL}$	*p*
1	-.11	.72	.46	.14
3	.51	.09	.51	.09
5	**-.64**	.02	-.03	.94
6	-.54	.06	.45	.14
7	-.47	.11	.32	.31
8	**-.62**	.02	-.27	.39
9	-.29	.35	-.29	.35
10	**-.73**	.00	-.16	.72
11	**-.70**	.01	-.48	.11
12	-.44	.13	-.22	.49
13	**-.56**	.05	-.10	.76
14	**-.71**	.01	**-.73**	.01
15	-.46	.11	.25	.44
16	-.35	.24	.00	1.00
17	**-.65**	.02	-.09	.79
18	-.38	.20	.12	.72
19	-.36	.23	-.01	.98
20	**-.72**	.01	-.16	.62
21	-.23	.46	.25	.44
22	-.43	.15	.14	.66
23	**-.66**	.01	-.18	.58
24	**-.81**	.00	-.21	.52
25	**-.73**	.00	-.19	.55
26	**-.66**	.01	-.05	.88
28	.41	.18	.41	.18
29	-.46	.11	-.42	.18
30	-.15	.63	.26	.42
31	-.29	.34	.01	.98
32	.49	.09	-.22	.50
33	-.08	.80	.44	.16
34	**-.79**	.00	.01	.98
35	**-.77**	.00	.19	.56
36	**-.59**	.03	-.05	.88
41	-.41	.19	-.41	.19
42	-.55	.05	.35	.27
43	-.02	.96	.25	.44
45	**-.61**	.03	-.01	.99
47	**-.84**	.00	-.37	.24
48	-.49	.09	-.04	.90

Bold: significant at $p < .05$ level.