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Original article

The relationship between skin conductance and upright stance body sway in healthy young subjects

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Abstract. *Study Objectives:* State anxiety and arousal levels are known to affect skin conductance level, spontaneous fluctuations of skin conductance, and postural control. In this study, we aimed to investigate whether skin conductance level and spontaneous fluctuations of skin conductance are associated with postural sway. *Methods:* Skin conductance and postural sway were continuously recorded for two minutes from 25 male participants aged 19 to 25. Skin conductance was recorded from the palmar surface of the third and fourth fingers of the non-dominant hands of the participants. A force platform sized of 40x40cm was used to determine postural sway. *Results:* No correlations were found between the number of spontaneous fluctuations number and any of body sway parameters. Our results indicated a linear relationship between the skin conductance and i) the root-mean-square of the body sway in the anteroposterior axis ($r=0.486$, $p<0.05$) and ii) the center of pressure sway area ($r=0.519$, $p<0.05$). *Conclusion:* Our findings pointed out that increased skin conductance level leads imply a cause effect relationship is associated with increased body sway in anteroposterior axis and increased body sway area.

Key words: Skin conductance level, postural sway, anxiety

Introduction

Control of body posture is a complex process that requires the processing of visual, vestibular, and somatic information and elaboration of appropriate motor commands to the skeletal muscles. Factors affecting postural control have been studied in recent years by many researchers. It has been reported that the emotional state and levels of anxiety affect postural control (1-3). Despite the basal ganglia, cerebellum and cortex are known as the upper structures of the central nervous system which is primarily responsible for the control of balance, the excessive activation of limbic structures may also cause interference in the control of balance (4). A considerable number of studies focused on the control of the balance of patients with anxiety disorder, some reported that the anxiety levels of healthy individuals too (1-7).

Measurement of the changes in skin conductivity (SCL), following vasodilation and secretion of sweating glands, is used for evaluating the activation level of the sympathetic system and correlated with the arousal level (8) and the emotional state (9,10). The relationship of skin conductivity and its spontaneous fluctuations (SF) with anxiety, was observed by many researchers (11-16).

We were not able to find in the literature research testing a possible association between skin conductivity and postural control. On the other hand, we encountered many studies related to separately postural control and skin conductivity mentioning emotional states and anxiety. It is aimed to investigate in this study whether the skin conductance is related to postural sway.

Materials and Methods

Participants

Totally 25 volunteers between the ages of 19 to 25 participated in our study. The participants were the ones who had none of the neurological or psychiatric illnesses or had no complaints about the loss of balance and the ones who have not taken any medication during the last 48 hours and they were all nonsmokers.

Skin conductivity measurements

Skin conductivity was recorded by 200 Hz sampling rate via Biopac MP-30 system with connecting AG/AgCl electrodes to the palmar surface of the third and fourth fingers of non-dominant hands of the participants. Skin conductivity level and spontaneous fluctuations (SF), as the measurement parameter on the skin conductivity records, were calculated. Skin conductivity level was calculated as the natural logarithm of the average skin conductivity values for 2 minutes.

Body sway measurements

A force platform having the size of 40 cm x 40 cm was used for the measurement of the center of pressure (CoP) oscillations. The load cells attached to every corner of the force platform (Esit SPA 300), were connected to four load cell amplifiers, the output of the amplifiers (NBC Elettronica BMAV type), were transferred to the computer through an analog digital converter board (Advantech PCI-1710). The CoP oscillations of participants were recorded for 2 minutes at 200 Hz sampling rate through software developed by the author. The participants were requested to stand erect with barefoot in parallel feet and look at a visual target at their eye level having 2 cm of diameter in a cabin where they cannot see the surroundings. Using the triggering signal generated by the skin conductance recording software, which was started by a user, the recording of the force platform was started simultaneously.

Calculations of body sway parameters

As evaluation parameters of force platform measurements, average in root-mean-square (RMS) normalized according to the averages of oscillations in the anterior-posterior and mediolateral axis, the length of CoP path and the area of CoP oscillations were calculated as (17);

$$RMS-AP=\sqrt{\frac{1}{n}\sum_{i=1}^{n}(X_i-\bar{X})^2}$$

$$RMS-ML=\sqrt{\frac{1}{n}\sum_{i=1}^{n}(Y_i-\bar{Y})^2}$$

$$PATH_{COP}=\sum_{i=2}^{n}\sqrt{(X_{i-1}-X_i)^2+(Y_{i-1}-Y_i)^2}$$

$$AREA=\frac{1}{4}\sum_{i=1}^{m}\left[(X_{i+1}+X_i)(Y_{i+1}-Y_i)-(X_{i+1}-X_i)(Y_{i+1}+Y_i)\right]$$

Where n is the number of total CoP points and, m is the number of points in a closed area of CoP.

Statistical Analysis

Pearson correlation analysis were executed for the statistical analysis of the data and the confidence limit was determined as 95%. All variables were tested for normality, which was assumed when skewness and kurtosis were between -1 and +1.

Results

The descriptive statistics values of the findings obtained from the participants were presented in Table-1.

By accepting SCL values as independent parameters, a possible correlation between anterior-posterior and media-lateral axis RMS, path, and area values, was tested; the following results were found; 1)the relationship between SCL and AP-RMS was statistically significant ($p<0.05$, $r=0.486$), 2) the relationship between SCL and ML-RMS was not significant ($p>0.05$, $r=0.295$), 3)The relationship between SCL and the CoP area was significant $p<0.01$, $r=0.519$), 4) The relationship between SCL and the path was not significant ($p>0.05$, $r=0.366$).

By accepting SF values as independent parameters, a possible correlation between anterior-posterior

Table 1. Descriptive statistical values of the data obtained

	N	Min.	Max.	Mean	Std. D.
SCL (μmho)	25	2,30	3,77	3,11	,33
SF (count)	25	4,00	23,00	14,24	5,79
AREA (cm2)	25	,98	15,20	5,52	3,85
PATH (cm)	25	23,30	51,78	32,50	7,62
AP-RMS (cm)	25	,03	,76	,20	,17
ML-RMS (cm)	25	,01	,20	,06	,04

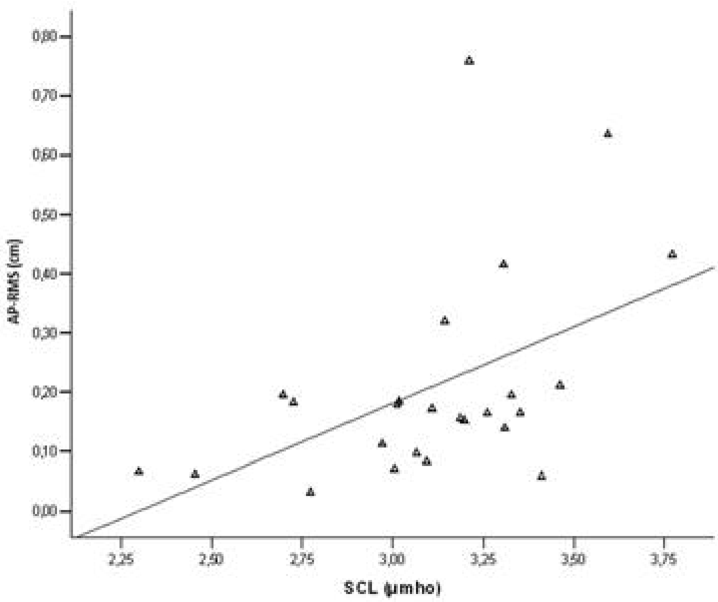

Figure 1. Correlation of SCL and AP-RMS. r=0.486

and media-lateral axis RMS, path, and area values, was tested; the following results were found; 1)the relationship between SF and AP-RMS was not statistically significant (p>0.05, r=0.001), 2) the relationship between SF and ML-RMS was not significant (p>0.05, r=0.118), 3)The relationship between SF and CoP area was not significant (p>0.05, r=0.152), 4)The relationship between SF and the path was not significant (p>0.05, r=0.251).

Discussion and Conclusion

When the findings obtained during our study, were studied together, while no relationship between SF and any other CoP oscillation parameter was found, a direct relationship between SCL and AP_RMS and CoP area parameters. Although the relationship between SCL and CoP path was not found as statistically significant, an increase in the CoP path values depending on the increase in SCL values.

Findings are indicating that SF count, which is one of the tonic activity parameters of the sympathetic part of the autonomous nervous system, decreases during anxiety (12,15). The fact that we were unable to find any correlation between SF and body sway parameters, makes us think that there is no connection between mechanisms responsible for the formation of SF which has not yet been clarified quite so far, and the mechanisms concerning postural control.

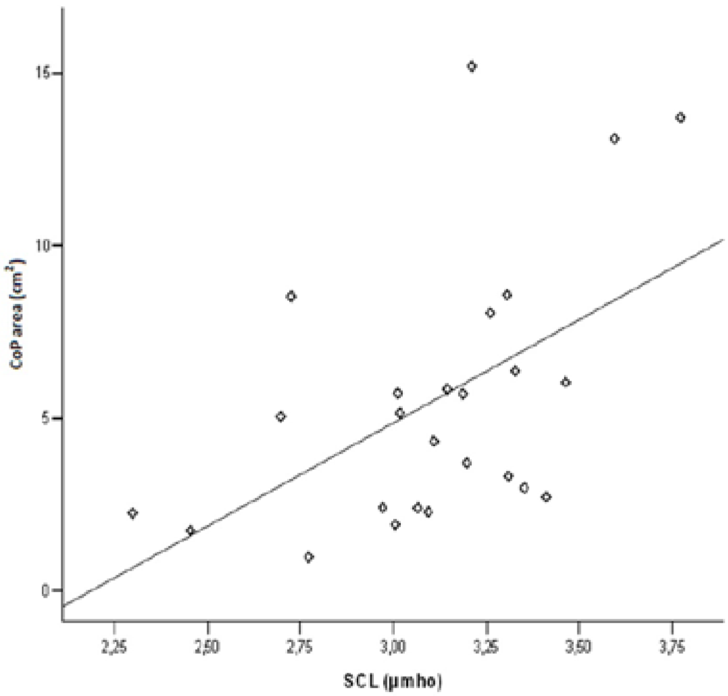

Figure 2. Correlation of SCL and CoP area. r=0.519

The relationship between SCL and anxiety level (8-16), the relationship between anxiety level and postural control (1-7) are findings that can be encountered frequently in the scientific literature. Wada et al declared that the anxiety level of healthy individuals was effective on the representation of visual information by postural control system (3). In their study, Ohno et al (2009) reported that there is a direct proportion between the change in the level of anxiety and CoP area alternation size and there is no significant correlation between CoP path (6). Our findings are consistent with Ohno's findings. Nevertheless, no other researcher reported the relationship between SCL and AP-RMS with or without anxiety. This condition suggests that there may be other factors having an impact on both SCL and postural control apart from anxiety.

The fact that there is a linear relationship between SCL and CoP area, and the fact that the insignificant relationship between SCL and CoP path, is a surprising result for us. This situation indicates that while the movement area of the CoP expands upon the increase in SCL value, the movement path of CoP does not extend sufficiently. Furthermore, this situation may also reveal that the path on which CoP cover may take longer regardless of the expansion of the CoP area. The lengthening of the route that the CoP travels over but at the same time there is no extension in the travel line indicates that minor corrections are carried out together with minimal deteriorations. On the other hand, the widening of movement area the deteriorations on the posture are in bigger amounts. In the context of our findings, it can be put forward that the factors increasing SCL value may lead to deteriorations that require extensive corrections over postural control.

As a consequence, our findings we obtained from our study are towards the fact that the factors influencing SCL, also affect the postural control. Nonetheless, our findings require enthusiastic support through further studies, which will be conducted on the same issue.

Conflicts of interest: The authors declare that there is no conflict of interest about this manuscript.

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