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Gender Variations in Electrodermal Activity among Medical Students in Response to Cold Pressor Test

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ABSTRACT

Objectives : To evaluate & compare the electrodermal activity(EDA) among males and females in response to cold pressor test.Thus know the differences in autonomic functions in males & females.

Materials & Method: In this experimental study Galvanic skin response(GSR) was the parameter measured for EDA. The sample size of our study was 70 MBBS students (35 males & 35 females)

Cold pressor test was performed by immersing hand in cold water (temp 4°C to 6°C) &changes in electrodermal activity(GSR) was recorded by using Biochart (version 1.0) device in our research lab.

Results: There was a significant increase in GSR after immersion of hand in cold water both in males and females. The baseline GSR value, GSR after immersion in cold water & the recovery GSR value were significantly higher in males compared to females.

Conclusion: There is substantial evidence of gender difference in the functioning of the autonomic system , including specific effects of both male & female sex hormones. As a generalisation, at least in humans there is a preponderance of sympathetic mediated responses in males and of parasympathetic in females.

Our data show that EDA(GSR) is such a simple and non invasive method that can be used reliably to measure the autonomic nervous system functions i.e., the sympathetic over activity during cold induced acute pain.

Keywords : *electrodermal activity,galvanic skin response, sympathetic, parasympathetic*

INTRODUCTION

The history of research into Electrodermal activity,which has been thoroughly reviewed by Neumann & Blanton , dates back to experiments performed in 1849 by Dubois – Reymond in Germany. The first experiment that showed a connection between sweat gland activity & current flow in skin was performed in Switzerland by Hermann & Luchsinger(1878).Three years later Hermann found that areas with stronger sweating such as palms and fingers showed greater skin current than other bodysites such as the wrist and elbow regions, which pointed to the importance of human sweat glands in electrodermal phenomenon[1].

Electrodermal activity is the property of the human body that causes continuous variation in the electrical characteristics of the skin. Historically , electrodermal activity has also been known as skin conductance,galvanic skin response(GSR), electrodermal response(EDR), Psychogalvanic reflex(PGR), skin conductance response (SCR) & Sympathetic skin response(SSR) &Skin conductance level(SCL)[2,3,4].

Skin conductance is not under conscious control. Instead, it is modulated autonomously by sympathetic activity. These autonomic sympathetic changes alter

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sweat and blood flow,which in turn effects GSR. The amount of sweat glands varies across the human body,being highest in hand and foot regions (200-600 sweat glands /cm2)[5]

Skin conductance is determined by the number and activity of sweat glands & their activity is stimulated by the sympathetic nervous system[6,7,8,9,10]

The autonomic nervous system is of importance in the natural history and treatment of number of pathophysiological states involving the CVS.These include HTN & diseases of vasculature as well as myocardial ischemia and cardiac arrhythmias[11]

An appreciation of gender differences in the structure and function of ANS is important to a full understanding of a number of common & important clinical presentations[12]

There are three different methods of measuring EDA : a) without the application of an external current,which is therefore called the endosomatic method and two exosomatic methods which either a) apply direct current (DC) via electrodes on the skin or apply alternating current (AC).The measurement of EDA as skin conductance using a DC,constant voltage methodology with silver – silver chloride electrodes and an electrolyte of sodium or potassium chloride has dominated the EDA literature for many decades.The measurement of exosomatic EDA with DC using a constant voltage system,the most widely applied method[13]

In most of the cases GSR is measured using a part of the skin having a lot of sweat glands.The skin on the palm or volar surface of hand contains 2000 sweat glands/ cm2.GSR measurement is relatively simple& has a good repeatability. Therefore the GSR measurement can be considered to be simple & useful tool for examination of ANS function especially the peripheral sympathetic system[14]

It uses just two electrodes which are placed on the fingers and act as if they were the two terminals of one resistance[15,16]

Immersion of limbs in cold water has long been known to induce pain.On immersion of hand incold water,there is an initial sensation of cold followed by pain,which rapidly increases in intensity reaching a maximum within about a minute[17]

The evaluation of of pain intensity has to rely on the patients self assessment.Therefore one may fail to assess pain intensity correctly in small children,unconscious or delirious patients[18,19,20,21].When patients cannot verbally communicate the pain , a fast reacting,objective,sensitive, specific and continuous method to monitor pain is needed[22]

When pain is experienced ,sweat glands are stimulated by sympathetic excitatory efferent neurons & sweat is released within 1-2 s whereby skin conductance increases due to decrease in skin resistance[6,22]

MATERIALS AND METHOD

This study was done in Research lab,Department Of Physiology,RVM Institute of medical sciences and research centre,during January 2018 to April 2018.70 healthy medical undergraduates including 35males&35females of 18-23years age group were included as subjects for this study.Subjects with H/O cardiovascular,respiratory abnormalities,H/O local pain or inflammation,H/O nerve injury to upperlimb were excluded from the study.

The protocol was approved by the Institutional Ethical committee.All participants were provided a written informed consent before the study related procedure.

PROCEDURE :

Each subject was called to the research lab,asked to sit & relax for 3-5min.Silver chloride electrode probe was used as a transducer to measure galvanic skin response. In this probe two sensors are attached with single cable. The two sensors are placed over the tips of index and middle fingers of dominant hand.Initially heart rate & Blood pressure of the subject were recorded.Three GSR values are recorded&analysed using BIOCHART software version 1.0 through physiograph.

1st recording :After the subject relaxes for a period of 3-5 min baseline recording at rest is taken for 1-2 minutes & GSR is noted.

2nd :With intact skin electrodes the subject is asked to immerse his / her dominant hand in cold water (temp 4-6°C)for a period of 2-4min & GSR value is noted.

3rd : The subject is asked to remove hand from cold water&after a gap of 2min recovery GSR is recorded.

RESULTS

TABLE:1 – GSR-TWO WAY SUMMARY

	GSR (kohm) Male		GSR (kohm) Female	
GSR-BASELINE (kohm)	207.886		197.286	
GSR-COLD (kohm)	217.171		206.143	
GSR-RECOVERY (kohm)	210.771		200.229	
Gen. Mean	211.943	***	201.219	***
C.V.	0.963		0.815	
F Prob.	0.000		0.000	
S.E.M.	0.345		0.277	
C.D. 5%	0.973		0.782	
C.D. 1%	1.292		1.039	

TABLE :2 – GSR-SUMMARY

Variable	MALE		Std. Err.	Std. Dev.	FEMALE		Std. Err.	Std. Dev.	T Test	Prob-ability		Mann Whitney	Proba-bility	
AGE in yrs	19.543	±	0.150	0.886	19.343	±	0.123	0.725	1.033	0.305		541.000	0.198	
GSR BASELINE(kohm)	207.886	±	1.683	9.958	197.286	±	1.356	8.024	4.904	0.000	***	252.000	0.000	***
GSR-COLD (kohm)	217.171	±	1.477	8.736	206.143	±	1.242	7.345	5.716	0.000	***	198.000	0.000	***
GSR- RECOVERY (kohm)	210.771	±	1.622	9.595	200.229	±	1.367	8.084	4.971	0.000	***	225.000	0.000	***

TABLE:3-Anova(Summary)

		GSR (kohm) Male		GSR (kohm) Female	
Replicates	34.00	259.23	***	178.31	***
Time	2.00	790.49	***	712.18	***
Error (A)	68.00	4.16		2.69	
Total	104.00	102.67		73.75	
General Mean	-9.00	211.94		201.22	
C.V.	-9.00	0.96		0.81	
C.D. 95%	-9.00				
Ai.- Aj.(Time)	-9.00	0.97		0.78	

The data of Galvanic Skin Response obtained were exported to Microsoft excel and then to WINDOWSTAT software for further analysis.Results were analysed statistically using ANOVA & t- test.

In males mean baseline value of GSR was 207.8 ± 9.95 kohm.After cold stimulation GSR value increased significantly to a mean value of 217.17 ±8.73kohm ($p < 0.05$).GSR returned to near baseline value of 210.77 ± 9.59kohm after cessation of cold stimulation.

In females the mean baseline value of GSR was 197.28 ± 8.024 kohm. After cold stimulation GSR value increased significantly to 206.14 ±7.34kohm ($p<0.05$). After cessation of cold stimulation mean value of GSR returned to near baseline value of 200.22 ± 8.084 kohm.

DISCUSSION

The objective of our study was to evaluate the changes in skin conductance due to autonomic changes during pain induced by cold pressor test&to observe the differences among males and females.

In the present study the GSR value was significantly increased in both males and females after pain induced by Cold Pressor test.The baseline GSR value,GSR after cold stimulation &GSR after cessation of cold stimulation were significantly higher in males compared to females. Similar result was obtained by many studies[9,23,24,25,26,27]

Electrodermal activity (GSR) includes both tonic and phasic components.

Tonic component includes skin conductace level(SCL),a baseline measure that changes slowly with altered arousal state and nonspecific fluctuations consisting of spontaneous responses that arise in the absence of apparent stimulation.Phasic responses are stimulus elicited and typically quantified by measuring the change in conductance that occurs in response to a discrete stimulus[28]

Galvanic skin response is a result of polysynaptic reflex activation .The efferent part of the reflex consists of myelinated sympathetic fibres that originates from intermediolateral horn of segments (T1-L2) of spinal cord and terminates on paravertebral ganglia.Post ganglionic fibres are nonmyelinated and innervates the eccrine sweat glands,the central part of reflex arc is not fully understood yet.It is presumably polysynaptic with a connection to a structure of hypothalamus VL part of brainstem,medial & basal part of the frontal lobe& medial part of temporal lobe.The afferent tract of the reflex arch depends on stimulus modality[29]

Human sweat glands receive signals primarily from sympathetic cholinergic fibres that use the neurotransmitter, Ach.Thus the pain induced by cold pressor stimulates sympathetic nerves which increases sweat production that decreases the resistance and increases conductance before the sweat is reabsorbed[30]

Data from literature indicates that skin sympathetic response recorded from palm of the hand and sole of the foot is a method that can reliably be used to describe a small section of the autonomic nervous system (sympathetic sudomotor function) and to calculate group differences[31]

Changes in skin conductance may be a promising tool for monitoring pain.One of the studies have shown that unlike heart rate&blood pressure,which are influenced by both sympathetic&parasympathetic nervous systems. Skin conductance is only influenced by the sympathetic nervous system[32]

A particular study evaluated pain response in preterm infants by analysing skin conductance fluctuations.The pain stimuli induced an immediate increase in emotional sweating & skin conductance fluctuations& when the pain stimuli are terminated the fluctuations decreased immediately[33]

As pain greatly modifies surgical stress response[34]monitoring of parameters of postoperative stress such as sympathetic tone could be helpful tool for assessment of analgesia.Increased sympathetic tone leads to a higher rate of firing in sympathetic postganglionic cholinergic neurons[33,35]

Responses to direct cooling may result from a number of mechanisms including direct effects on cutaneous venous α-AR[36]

Gender differences in the autonomic nervous system may be present because of developmental differences or due to the effects of prevailing levels of male or female sex hormones.

Differences in autonomic system may be due to differences in afferent receptor stimulation in central reflex transmission in the efferent nervous system, in post synaptic signalling.There may be

effects due to different size or number of neurons, variations in receptors,differences in neurotransmitter content,metabolism as well as functional differences in various components of reflex arc[37].

A study in which sympatho adrenergically mediated vasoconstriction was evaluated.forearm vasoconstrictor responses to intraarterial noradrenaline were also significantly less in women than in men[38].Oestrogen has been shown to modulate neuronal activity both in a receptor dependent & independent manner[39]

These observations prompted to propose the novel hypothesis that oestrogen acts within central autonomic nuclei to regulate autonomic tone.The principal central nuclei involved include the insular cortex, lateral hypothalamic area,central nucleus of amygdala, parabrachial nucleus,NTS,NA, RVLM[40]

It has been shown that sex hormones affect multiple aspects of central neuronal function oestrogen increased the density and affinity of muscarinic receptors.

CONCLUSION

There is substantial evidence of gender difference in functioning of autonomic system , including specific effects of both male& female sex hormones. As a generalisation ,at least in humans there is a preponderance of sympathetic mediated responses in males and of parasympathetic in females.

Our data show that EDA(gsr) is such a simple and non invasive method that can be used reliably to measure the autonomic nervous system functions i.e.,the sympathetic over activity during cold induced acute pain.

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