Original Research Article

THE IMMEDIATE EFFECT OF STEAM BATH AND SAUNA BATH ON HEART RATE VARIABILITY AND BODY COMPOSITION IN OBESE INDIVIDUALS: A COMPARATIVE STUDY

ABSTRACT:

AIM: The present study was designed to evaluate and compare the immediate effects of steam bath and sauna bath on body composition and Heart Rate Variabilities in individuals with obesity.

Study Design: Prospective randomised comparative trial

Materials and Methods: Participants visiting Shantivana Nature cure hospital with age ranging from 18 to 32, without any comorbidities and BMI more than 31 kg/m^2 were appraised about the study protocol and after getting informed consent were divided into Steam bath group (n = 50) and Sauna bath group (n = 50) and were administered one sitting of Steam bath and sauna bath for 20 minutes. The HRV and Body Fat Analyser data was recorded before and after one sitting of treatment. The data was analysed using JASP (version 0.14.1.0) software and parametric and non-parametric tests were employed based on the normal distribution.

RESULTS: Significant changes were observed in BMI ($p= 0.022$), TBW ($p<0.0001$), HR ($p= 0.002$), RRI ($p< 0.001$), NN50 ($p=0.013$), PNN50 ($p=0.0001$), variables in the Steam bath group after comparing with the baseline. In the Sauna bath group significant changes were seen in BW ($p<0.001$), BMI ($p<0.001$), FFM ($p= 0.004$), BMR ($p< 0.001$) SBP ($p= 0.008$), HR ($p<0.001$), Mean RR ($p<0.0001$), RMSSD ($p=0.005$), PNN50 ($p<0.0001$), VLF ($p<0.0001$),

LF (p<0.001), HF (p<0.001), LF/HF (p<0.001). When comparing steam bath with sauna bath group, the variables DBP (p=0.002), HR (p= 0.021), RMSSD (p<0.001), RMSSD (p<0.001), NN50 (p<0.001), pNN50 (p<0.001), VLF (p<0.001) showed significant changes.

CONCLUSION: The present study concludes that single dose of steam bath and sauna bath reduces the body weight by acting on the total body water percentage, reduces diastolic blood pressure, and causes vagal dominance. Sauna bath also increases basal metabolic rate which further helps in improving metabolism in the body and further helps in reducing body weight.

KEYWORDS: Naturopathy; Obesity; Steam Bath; Sauna Bath; Body Composition; HRV.

1. INTRODUCTION:

Obesity is now recognized as a chronic non-communicable disease which is defined as a condition of abnormal or excessive fat accumulation in adipose tissue to the point at which health risk is increased. [1] Body Mass Index (BMI) above 25 kg/m^2 is considered to be characteristic feature of obesity in Asian Indians according to the recent WHO report. [2] Obesity is strongly associated with other metabolic disorders including diabetes mellitus, hypertension, dyslipidemia, gall bladder disease, osteoarthritis, sleep apnoea, some cancers and higher prevalence of cardiovascular diseases. [3, 4]

Evidence suggests that most of the obese patients are seeking alternative forms of medicine as there are less treatment options available in conventional medicine. [8] The users of complementary and alternative medicine (CAM) tend to pursue generally healthy lifestyles, which suggest that they may be open to additional recommendations toward optimizing their health. [9] Whole systems of complementary and alternative medicine (WSCAM) are defined as “complete

systems of theory and practice that have evolved independently from or parallel to allopathic (conventional) medicine.

Naturopathy is a system of man building in harmony with the constructive principles of nature on physical, mental, moral and spiritual planes of living. [11] The modalities included in naturopathy are diet therapy, fasting therapy, massage therapy, air therapy, mud therapy, hydrotherapy, magnet therapy and acupuncture. [12]

Hydrotherapy, one of the naturopathic treatment modality consists of internal and external use of water in various forms such as ice, water and steam with desired pressure, duration, applied to the preferred site for health promotion and disease management. [13]

Steam bath is one of the most important time-tested water treatments which induce perspiration in a most natural way and has health benefits such as increased basal metabolic rate, weight loss and relaxation by having a profound impact on physical, biochemical and hematological parameters. [14, 15]

Sauna bathing is characterized by high temperature and dry air which helps to deeply cleanse the skin, promote weight loss, improve blood circulation, accelerate muscle recovery, relieve tension headaches, and induce a deeper and more relaxing sleep. [16, 17]

Several studies found that obesity is associated with reduced heart rate variability (HRV) which forms a potent risk factor for cardiovascular diseases. Obese patients have increased sympathetic activity and a withdrawal of vagal activity and these autonomic disturbances improve after weight loss. [18] Hence this study is designed to evaluate and compare the effects of steam bath and sauna bath on the HRV and body composition analysis of obese individuals.

A Study conducted by Hussain J et al., have concluded that regular dry sauna bath has potential health benefits. [19] Shiralkar et al., had conclude that the continuous seven days of steam, sauna shows the significant decrease in the

fasting blood glucose levels in the peoples who do not practice any exercise and also athletes. [20]

A study by Pilch W and his colleagues concluded that the wet sauna where the humidity is higher causes a much greater load of heat for the organism compared to the dry sauna bath. [21] Panov S.F concluded there was significant increase in blood gastrin, aldosterone level and decrease in the concentrations of cortisol after steam bath. [22]

A study published in International Journal of Biometeorology by Soomin Lee and colleagues concluded that the morning mist sauna has reduced burden on cardiovascular system and that skin temperature was maintained compared to other bathing methods and that it improves the work efficiency during the task period of the day. [23] Sathoshi Iwase and his associates concluded that mist sauna is safer sauna bathing system which has more efficiency on circulatory and thermoregulatory function when compared to dry sauna bathing. [24]

A study published in Journal of Occupational Health concluded that healthy subjects exposed to heated temperature of 37^0C with humidity of 75% for 30 minutes showed significant increase in heart rate, body temperature, LF: HF ratio, subjective symptoms and significant decrease in HF component when compared to exposure of thermo-neutral condition. [25] Another study by Soomin Lee and his associates concluded that full immersion and mist sauna are effective in facilitating recovery from muscle fatigue due to increased skin circulation and concentration of oxygenated hemoglobin. [26]

These evidences suggest the effects of steam bath and sauna bath separately. Hence the present study was designed to evaluate the immediate effects of steam and sauna bath in subjects with increased body weight and to compare the effects on body compositional changes.

2. METHODOLOGY:

2.1 Subjects:

A total of 150 subjects were screened using the BMI classification chart and 100 subjects who satisfied the inclusion and exclusion criteria were recruited from inpatient facility of Sri Dharmasthala Manjunatheshwara Yoga and Nature cure hospital, Shanthivana, Dharmasthala.

2.2 Ethical considerations:

Subjects who fulfilled the inclusion criteria were given information sheets having details regarding the nature of study and intervention to be used. Subjects were given enough time to go through the study details mentioned in the information sheet. They were allowed to ask any questions and if they agree to participate in the study they were asked to sign the informed consent form (sample copy is enclosed in 10.0) which was mainly provided in the English language. All expressed their willingness to participate in the study by giving signed informed consent. Approval was obtained from the Institutional Ethical Committee, as all tests were essentially non-invasive.

2.3 Method of Collection of Data:

2.3.1 Criteria for Diagnosis:

The diagnosis was made according to the redefined version of World Health Organization (WHO) classification criteria of BMI (Table 1) and subjects with BMI above 25 kg/m^2 were recruited for the present study. [2]

2.3.2 Inclusion Criteria:

- Age 18 to 40 years
- Subjects who are diagnosed as obese according to WHO classification of BMI
- Gender - Male and Female

2.3.3 Exclusion Criteria:

- Subjects with open wounds
- Subjects with Fever
- Females under menstruation

- Subjects who are intolerant to heat
- Subjects consuming alcohol and nicotine.

2.4 Study Setting:

The study subjects were identified. Signed informed consent was obtained from all the participants after an appraisal about the study protocol.

2.4.1 Design: A prospective randomized comparative trial. Subjects were recruited as and when they arrived to the inpatient facility.

2.4.2 Sample size: Total number of subjects (n) = 100

2.4.3 Grouping: Subjects were randomly allocated to two groups by odd and even number chart. A chart with numbers from 1 to 100 was prepared and subjects were allocated either to steam bath (odd number) or to sauna bath (even number) as and when they arrived.

Group 1: Steam bath (n =50)

Group 2: Sauna bath (n = 50)

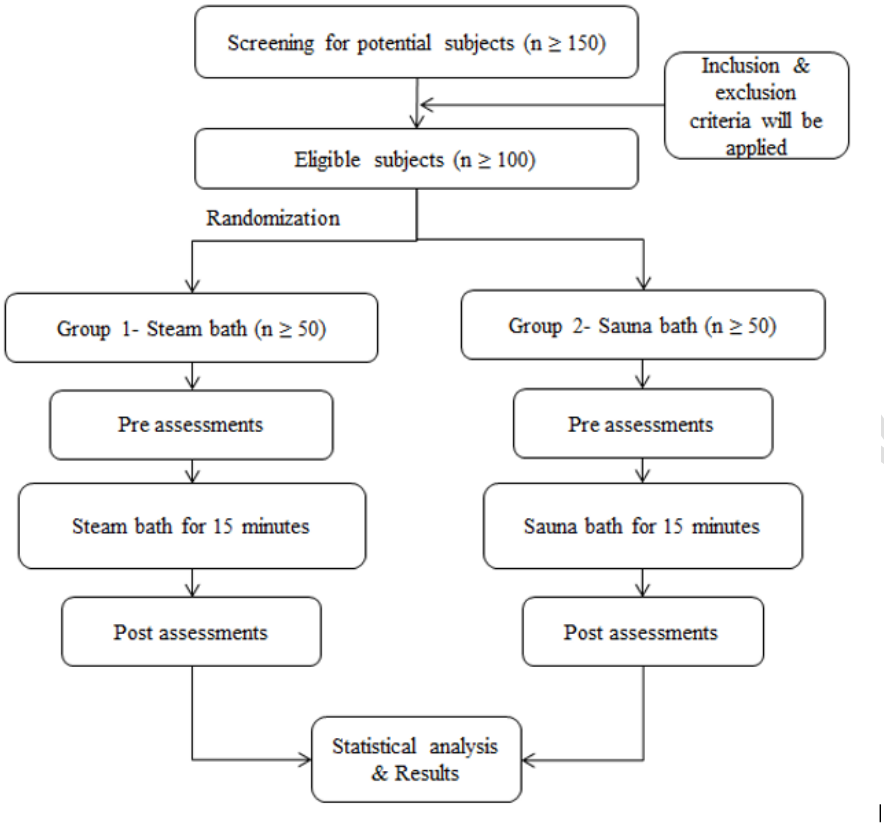

Fig.1 Illustration of the study plan

2.5 Intervention:

2.5.1 Steam Bath:

- **Temperature**: 43.3^{0}C to 54.4^{0}C (110F to 130F) with 100% humidity
- **Duration** - 15 minutes
- **Apparatus**: A modular steam bath cabinet has a steam generating system including a heated, inclined evaporating surface over which heated liquid flows to cause evaporation of the liquid. Any known evaporated liquid such as water is collected, reheated and recirculated. The steam generating system is part of the module, which includes the floor of the cabinet.
- **Procedure –** Prior to the intervention the subjects were asked to drink 2 to 3 glasses of water and take a cold shower before entering the steam chamber. The subjects were made to sit in the chamber with minimal clothing with a cold

compress on head. After the intervention the subjects should dry themselves with a dry towel and dressed up for the post assessment which was done after 5 minutes of intervention. [196]

2.5.2 Sauna Bath:

- **Temperature:** 80^0C to 100^0C (176F to 212F) with 10-20% humidity [17]
- **Duration:** 15 minutes
- **Apparatus:** Sauna bath chambers are improved replacements of the old-time Turkish bath chambers. A cabin, specially made with pine wood is used for this purpose. Depending on the size of the cabin, two to ten patients could be treated at a time.
- **Procedure:** Before entering the chamber, the subjects were asked to drink 2 to 3glasses of water. While in the cabin the subject was asked to frequently rub himself to encourage dilation of the surface vessels. After the intervention subjects were advised to quickly dry himself**.** Post interventional data was recorded after 5 minutes. [196]

2.6 Assessment:

2.6.1 Body weight and composition analysis: Body weight and composition was measured by bio-impedance equipment (Tanita SC-330, Tanitacorp, Japan) which provided a print-out of measured impedance and calculated body weight and composition. Subjects were standing on the metal sole plates of the machine. All measurements were made after a period of at least 10 min standing to minimize potential errors from acute shifts in fluid distribution. Body composition for all subjects were estimated using the standard prediction equations rather than those designated for athletes, regardless of the exercise habits of the participants. [197, 198]

2.6.2 Blood Pressure: Blood pressure was measured in the supine position. A rubber cuff was wrapped around the subject's upper arm and inflated to a pressure of 20mmHg above the level at which radial pulsation can no longer be felt. Place the stethoscope lightly over the brachial artery and reduce the

pressure in the cuff until the first sounds are heard. This first Korotkoff sound correlates with systolic blood pressure. With further lowering of the pressure in the cuff, the sounds die away completely as flow is unimpeded by the cuff which is called as fifth Korotkoff sound, which correlates with the diastolic blood pressure. [199]

2.6.3 Heart Rate Variability: The HRV was recorded for 7 minutes before and after the intervention. The Electrocardiogram (ECG) was be assessed using MP36 data acquisition system (Biopac Student Lab). The ECG was recorded using Ag/Agcl pre gelled electrodes, standard bipolar limb lead II configuration and an AC amplifier with 1.5 Hz high pass filter and 75 Hz low pass filter settings (Biopac, USA). The sampling rate would be 1024 Hz

2.7 Data Extraction:

2.7.1 Blood Pressure: The blood pressure was recorded manually by mercury sphygmomanometer.

2.7.2 Body weight and composition: The data were extracted in the form of a printed slip in which Body weight and Body composition in terms of FFM, TBW and BMR were recorded.

2.7.3 Heart Rate Variability: From the digitized ECG data, the R waves was detected to obtain a point event series of successive R-R intervals, from which the beat to beat heart rate series was computed. The data recorded was visually inspected off-line and only noise free data was included for analysis. Data was averaged for each 5 minute block period. The HRV power spectrum was obtained using Fast Fourier Transform analysis (FFT). Frequency domain and time domain components were analyzed separately.

- **Frequency domain analysis**-The energy in the HRV series of the following specific bands were studied i.e. low frequency component (LF), and high frequency component (HF). The LF and HF values were expressed as normalized units. LF: HF was also calculated.

- **Time domain analysis-** The following components of time domain analysis of HRV were obtained: the HR (heart rate), the mean RR interval (the mean of the intervals between adjacent QRS complexes or the instantaneous heart rate); RMSSD (the square root of the mean of the sum of the squares of differences between adjacent NN intervals); NN50 (the number of interval differences of successive normal to normal intervals greater than 50ms), and pNN50 (the proportion derived by dividing NN50 by the total number of NN intervals). [200]

2.8 Data analysis:

The data was tabulated in excel and statistical analysis was done using Jasp software (Version 2.0). Data were checked for normal distribution using the Shapiro-Wilk test and analysed by using parametric tests. A P-value of less than 0.05 was accepted as an indicator of significance.

3. RESULT:

100 subjects were randomly assigned into Steam bath (n=50) and Sauna bath group (n=50). Baseline and post-intervention assessments of each intervention was done. Statistical analysis was done to compare baseline and post-intervention assessments of between the group (Independent t test and Mann Whitney U test) and within the group (Wilcoxon signed rank test). There were no significant differences between the spinal bath and spinal compress group at baseline. The demographic variables of the subjects who participated in this study are given in table 6 and 7.

Significant changes were observed in BMI ($p= 0.022$), TBW ($p<0.0001$), HR ($p= 0.002$), RRI ($p< 0.001$), NN50 ($p=0.013$), PNN50 ($p=0.0001$), variables in the Steam bath group after comparing with the baseline. There was no significance seen between baseline and post assessment of SBP (0.436), DBP (0.252), RMSSD (0.367), VLF (0.626), LF (0.626), HF (0.787), LF/HF (0.762), BW (0.063), FFM (0.81), and BMR (0.9).

In the Sauna bath group significant changes were seen in BW (p<0.001), BMI (p<0.001), FFM (p= 0.004), BMR (p< 0.001) SBP (p= 0.008), HR (p<0.001), Mean RR (p<0.0001), RMSSD (p=0.005), PNN50 (p<0.0001), VLF (p<0.0001), LF (p<0.001), HF (p<0.001), LF/HF (p<0.001), and there were no significant changes in in DBP (p=0.178), NN50 (p= 0.877) TBW (p= 0.103) variables. While comparing the baseline and post assessment value of and there was no statistical significant seen.

While comparing the post-assessment data of steam bath with sauna bath group, the variables DBP (p=0.002), HR (p= 0.021), RMSSD (p<0.001), RMSSD (p<0.001), NN50 (p<0.001), pNN50 (p<0.001), VLF (p<0.001). There were no significant changes in Mean RRI (0.438), LF (0.329), HF (0.406), LF/HF (0.296), BW (0.759), BMI (0.304), FFM (0.595), TBW (0.448) and BMR (0.81). did not showed statistically significant results.

Table 1: Comparison between Steam and Sauna on Body weight, BMI, FFB, TBW and BMR.

Variables	Groups	Mean		Std. deviation		Within the group	Between the
		Pre	Post	Pre	Post		

							group[#]
Variables	Groups	Mean		Std. deviation		Within	Between
BW	Steam	82.81	82.67	14.264	14.222	0.063[*]	0.759
	Sauna	83.07	82.69	12.48	12.26	**<0.001**[^]	
BMI	Steam	30.654	30.57	4.074	4.099	**0.022**[*]	0.304
	Sauna	31.26	31.05	3.73	3.596	**<0.001**[*]	
FFM	Steam	53.204	53.162	11.452	11.398	0.81[*]	0.595
	Sauna	54.54	54.33	10.674	10.938	**0.004**[*]	
TBW	Steam	47.25	47.59	3.642	3.642	**<0.001**[^]	0.448
	Sauna	48.852	48.612	5.151	4.817	0.103[*]	
BMR	Steam	6729.08	6723.96	1227.86	1214.68	0.9[*]	0.81
	Sauna	6527.6	6621.64	1081.53	1072.24	**<0.001**[*]	

Table 2: Comparison of Steam and Sauna on blood pressure and HRV:

Note: Values in bold suggests Significance. * = Wilcoxon Signed rank test; ^ = Students t test; # = Mann Whitney U test.

		Pre	Post	Pre	Post		
SBP	Steam	120.62	122.98	11.584	12.345	0.436	0.591
	Sauna	121.32	124.08	4.635	8.896	**0.008**	
DBP	Steam	78.28	76.74	8.273	7.483	0.252	**0.002**
	Sauna	79.88	80.88	3.967	5.363	0.178	
Mean HR	Steam	82.157	84.929	18.009	16.373	**0.002**	**0.021**
	Sauna	80.341	101.009	7.812	31.564	**<0.001**	
Mean RRI	Steam	796.458	749.626	118.026	117.345	**<0.001**	0.438
	Sauna	797.898	715.094	86.963	167.120	**<0.001**	
RMSSD	Steam	77.17	73.846	98.067	91.161	0.367	**<0.001**
	Sauna	263.366	418.091	362.169	716.38	**0.005**	
NN50	Steam	62.38	47.16	68.12	65.77	**0.013**	**<0.001**
	Sauna	104.76	145.24	77.36	137.428	0.877	
PNN50	Steam	26.064	31.308	26.771	86.938	**0.03**	**<0.001**
	Sauna	29.424	49.16	23.919	35.575	**<0.001**	
VLF	Steam	34.804	36.512	20.324	21.502	0.626	**0.01**
	Sauna	36.584	24.38	16.499	13.235	**<0.001**	
LF	Steam	51.122	48.65	22.892	23.52	0.626	0.329
	Sauna	55.766	41.076	13.762	14.323	**<0.001**	
HF	Steam	52.286	51.35	21.254	23.52	0.787	0.406
	Sauna	43.638	58.414	13.69	14.573	**<0.001**	
LF/HF	Steam	1.434	1.736	1.371	2.015	0.762	0.296
	Sauna	1.456	0.892	0.584	0.807	**<0.001**	

6. DISCUSSION

In the present study it revealed significant decrease in Fat%, increase in Lean muscle mass and water%, significant increase in BMR in sauna bath and significant changes in components of HRV, blood pressure and autonomic nervous system followed by both interventions.

Fat body mass includes all of the body's fatty tissue, while lean body mass includes everything else such as the bones, organs, and muscles. Therefore, the term lean muscle refers to the fact that muscle is part of lean body mass. These two components are usually measured in a ratio, or by percentage. Body fat percentage, the amount of the body composed of fat mass since the body fat and lean muscle mass are inter related any change in fat% results in change of lean muscle mass. Hence the changes observed in body composition needs to be studied further to understand the lasting influence of either sauna bath or steam bath.

Earlier studies have reported a possible sympathetic drive following Sauna bath which would last for as long as 15 minutes to 1 hour duration to return back to its base line. It is clear from the present study that the sympathetic tone increases following sauna bath as evidenced by an increase in Low frequency and ratio of low frequency and high frequency component of HRV after 5 minutes of sauna bath intervention. In contrast the high frequency components decreased after 5 minutes of sauna bath intervention, whereas no such changes were observed after steam bath intervention. Hence, the underlying mechanism regulating physiological functions following an exposure to moist heat (steam) needs to be further understood. The factors which might have influenced the results include the duration of steam bath (might take more time to produce similar effects as that of sauna bath), exposure to moist heat (compared to the dry heat of sauna), exposure to ambient temperature immediately after the intervention which facilitates quicker cooling. In a systemic review it was reported that the heart rate accelerates up to twice the resting rate and even more, diastolic and mean arterial pressures decrease, with practically no change in the systolic pressure. [201]

The changes were all suggestive of increased sympathetic activity and/or increased vagal modulation. These were an increase in the LF power of HRV, LF/HF ratio and a decrease in the HF power. As described above, most of the changes after sauna bath were suggestive of increased activity in the different subdivisions of sympathetic nervous system activity, though some variables are

regulated by several factors. The heart rate for example, is regulated by dual innervations (sympathetic and vagal), as well as humoral factors. [201] [202]

The LF power significantly increased after sauna bath session. Conversely, the HF power decreased after sauna bath. The increase in LF after sauna bath could reflect either a change in sympathetic or parasympathetic activity as described above. Taken together the results suggest that sauna bath is associated with changes in the autonomic nervous system suggesting vagal withdrawal. Results of our study in relation to blood pressure and heart rate reveal that Sympathetic neural control of arteriolar resistance offers a powerful mechanism to regulate regional blood flows to individual Organs and tissues. As the arterioles are the major contributors to total peripheral resistance, sympathetic control also plays a principal role in the regulation of systemic blood pressure. However, numerous factors can influence neurogenic constriction of vascular beds, individual vessels, and even different segments of the same vessel. [204]

These include the density of sympathetic innervation, density and subtype of adrenergic receptors, differences in nor epinephrine kinetics, release of co transmitters, and local factors such as the degree of basal tone, the concentrations of vasoactive tissue metabolites, and vessels end structure. Studies conducted on evaluating the effect of heat stress on baroreflex responses summarized that heat stress does not alter the baroreflex control of heart rate. The exceptions are from a few studies in which the change in heart rate is attenuated during relatively small spontaneous oscillations in blood pressure. Possibly, these observations are due to reduced cardiac vagal activity associated with heating. [205]

When greater changes in baroreceptor loading were caused either mechanically or pharmacologically, the baroreflex gain of the blood pressure–heart rate relationship was unchanged during whole-body heating, cutaneous post synaptic vasoconstrictor responses are attenuated by local and indirect whole-body heating, whereas muscle vasoconstrictor responses are not impaired when

muscle temperature is elevated approximately 4°C. Sauna bath reduces Peripheral resistance resulting in decreased blood pressure. [206]

6.1 Strength of the Study:

- The present study involved 100 subjects with obesity and evaluated the immediate effect of Steam and Sauna. Both subjective as well as objective components were assessed. The participants did not face any side effects during intervention or evaluation. Both interventions gave positive results.

6.2 Limitations of the Study:

- Only Immediate effects were assessed.
- Only one sitting of intervention was observed.

6.3 Scope for future research:

- Further studies with long term effects can be designed with more biochemical indices to evaluate the long-term effect.

7. CONCLUSION:

The present study concludes that single dose of steam bath and sauna bath reduces the body weight by acting on the total body water percentage, reduces diastolic blood pressure, and causes vagal dominance. Sauna bath also increases basal metabolic rate which further helps in improving metabolism in the body and further helps in reducing body weight. This can be applied as a therapy for managing obesity and its complications.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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