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RESEARCH ARTICLE

Effect of Yoga Breathing Manuevers (Shitali and Sitkari Pranayama) on Heat Stress Management

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ABSTRACT

Background: Heat stress is a common problem, particularly in a tropical country like India. Ancient Hatha Yogic texts suggest that practice of Shitali and Sitkari pranayama (SSP) to give relief from thirst sensation and the feeling of coolness in the body. This motivates us to ask the following research question: Can a common person get benefit through these pranayamas in a hot and humid climate?

Objectives: To study the role of yoga breathing maneuvers i.e. Shitali and Sitkari pranayama practice (SSP) in the heat stress management.

Methods: During one hour heat exposure (HEx) at 40±2˚C, humidity 78±2%, and WBGT 37.5±0.3˚C, 20 healthy, young, yoga practitioners did SSP and again without SSP after 3 Weeks. Their bodyweight (Bw), skin temperature (Tsk), heart rate (HR), oral temperature (Tor) and thirst sensation were periodically monitored.

Results: The sweat loss, without SSP (320±105.63 gm) was found to be significantly higher ($p<0.05$) than with SSP (240 ± 82.08 gm). In case of the 1st set, the thirst sensation significantly reduced ($p<0.05$) from 29.35±11.85 mm to 22.2±12.57 mm; whereas for the 2nd set, it significantly increased ($p<0.05$) from 21.25 ±9.52 mm to 34.25 ±13.22 mm. However, the other three parameters did not show any significant difference between the two sets but In HEx, Mean Tor and HR (45th and 60th minute) were relatively lower with SSP than without SSP.

Conclusion: SSP helps to combat heat stress by preserving body fluid and better control over the thirst sensation.

KEYWORDS:
Shitali pranayama, Sitkari pranayama, heat stress, sweat loss, thirst sensation.

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INTRODUCTION

Hatha yoga, an ancient Indian system is reported to have beneficial effects on body and mind [1]. It works holistically on different physiological systems [2-4]. Its practice involves modulation of different bodily functions which sometimes goes into the domain of physiological extremes and yogis develop tolerance or adaptations to extremes of stressful environment which are not usually observed in normal healthy persons [5,6]. It was found that *Tibetan g-tum-mo* yoga practitioners could raise their skin temperature by 8.3^0 C [7]. Another study showed that hatha yoga practitioners among common men (soldiers) could maintain core temperature in a better way when exposed to cold chamber (10^0 C) [8]. One of the important components of yogic practices is pranayama which involves different types of breathing maneuvers. Yoga texts describe varieties of pranayamas with their beneficial effects to its practitioners [9]. Scientific studies were done on different types of pranayamas and slow breathing on cardiovascular, respiratory, and neuro-endocrine systems both during its practice and also on its effects after long term practice [10-13]. Two pranayamas i.e. *Shitali* and *Sitkari* pranayama have been described by ancient yoga texts as having the potential to give a cooling effect on the body and also to reduce thirst sensation [9,14]. Here in after Shitali and Sitkari pranayama practice will be expressed as SSP throughout text. Yoga has evolved in India, major part of which comes under tropical region. So, there are possibilities of SSP being devised by hatha yogis considering the need of the local climatic conditions. To the best of our knowledge, so far, no scientific studies have been done on the potentiality of SSP in heat stress management. Heat stress and related disorders are common problem from the shop floor of industries to the cultivators in agricultural sector and it does not confine to the geographical confines of any country or region. So, the purpose of this study was to scientifically evaluate the potentiality of *SSP* in heat stress management.

MATERIALS AND METHODS

Subjects

Twenty male subjects from the university student community, having similar lifestyle and food habits and practicing yoga at least for one year volunteered for this study. Subjects suffering from diseases like; diabetes, hypertension, any other cardio-respiratory problems, or undergoing treatment/medication for any diseases before and during the experiment, under intoxication like smoking, tobacco chewing, consuming alcohol and who were not practicing yoga were excluded from this study. Their physical characteristics were: age 27.4±3.26 yrs.; height163.33 ± 4.59 cm and body weight 61.86 ± 10.26 kg. The purposive sampling was adopted for this study. Their informed consent to participate in this study as subjects was taken after explaining the purpose and protocol of the study. Approval of the institutional ethical committee for human trial for this study was also obtained.

METHODOLOGY

The study was conducted in an improvised hot chamber where temperature 40±2°C, humidity 78±2%, and WBGT 37.5±0.3°C was maintained. During the experiment of 1st set the average ambient temperature was 36±2°C (DB), humidity 76±2%, but the temperature was slightly lower during the 2nd set of experiment 34±2°C (DB), humidity 80±2%. The hot chamber was situated adjacent to an air-conditioned room where temperature could be regulated up to minimum 17±3°C. This adjacent room was used for recordings before and after heat exposure (HEx). This room was also used, if required in exigencies to give comfort in case of heat exhaustion. Precaution was also taken by arranging sufficient amount of purified drinking water, glucose etc, along with nearby medical facilities located less than1 km where medical person were available in an emergency situation. There were two sets of experiments on the same subjects on different days within a span of 30 days. In the 1st set, subjects did SSP during HEx, and in the 2nd set subjects did not perform SSP during HEx. The procedure followed for recording various parameters before and after HEx was as follows: At first subjects were sitting in thermo-neutral room (temperature 28±2ºC) and their heart rate (HR) was recorded digitally by finger pulse oximeter. Skin temperature (Tsk) and oral temperature (Tor) were recorded by digital thermometer (curamed Germany) and clinical thermometer (dynosure, China) respectively. Bodyweight (Bw) was recorded by human weighing machine (Crown, India) with minimum clothing (only with shorts on). Their thirst sensation also was measured by visual analog scale. Thereafter, subjects were inducted for one hour in the hot chamber. This one-hour period was divided into three parts. First 15 mins subjects did not perform SSP. In the next 30 minutes they continuously performed SSP alternately according to their own choice (either Shitali or Sitkari first). The last 15 minutes again went without doing SSP. Various parameters were measured before HEx and at several points of time, such as, after 15 min, 25 min, 30 min, 35min, 45min and 60 min of HEx, as well as immediately after HEx. During HEx, the subjects were told not to speak with each other. After 10 minutes of HEx, the thermometer was inserted in the sublingual position for measuring Tor and kept till 15 minutes. During this period Tsk and HR were monitored. Then at the end of 15 minutes, subjects started doing SSP. Again, HR and Tsk were measured in different points of time while performing SSP. In the last 5 minutes (55-60 mins) Tor and other parameters were monitored. During HEx only three parameters (Tsk, HR, and Tor) were periodically taken. Immediately after HEx their thirst sensation score was taken along with Bw after wiping out the sweat. The same protocol was followed in the 2nd set of experiments when subjects did not practice *SSP*. In this study, the clinical thermometer which was used for measuring Tor was checked with another calibrated thermometer. Every time the thermometer was placed in sublingual position it was kept for minimum 5 minutes to get accurate Tor. Subjects marked their thirst sensation /feeling on a visual analog scale having length of 100 millimeters. Prior to the final trial, they had practiced marking their thirst sensation on the visual analog scale several times on other days. No subject had taken food, water or any liquid an hour before the experiment began as well as throughout the period of the experiment. Bodyweight was measured before and after HEx. The difference in bodyweight between before and after HEx was considered as the body fluid/sweat loss. The statistical analysis for comparisons of various data on different time points were done by paired t-test.

Technique of SSP

Shitali pranayama:

This pranayama is performed by first sitting in any comfortable meditative *posture, keeping* the back straight and both hands on the knees. Next the tongue is brought out and folded. In this manner one should draw in air through *the* *mouth and then* exhale slowly through both the nostrils [14]. (Fig.1-A)

Sitkari pranayama:

This pranayama is also performed by first sitting in any comfortable meditative *posture, keeping* the back straight and both hands on the knees. Then the tip of the tongue is touched with the hard palate. In this position the upper and lower rows of teeth are joined and air is drawn in through the mouth making a seething sound (‘sit’). After inhalation air is exhaled through both nostrils [14]. (Fig.1-B)

RESULTS

In 1st set with SSP, the sweat loss (240 ± 82.08 gm) was found to be significantly lower ($p<0.05$) than without SSP (320±105.63 gm) in the 2nd set (Fig-2). In case of the 1st set, the thirst sensation significantly reduced ($p<0.05$) from 29.35±11.85mm to 22.2±12.57 mm; whereas for the 2nd set, it significantly increased ($p<0.05$) from 21.25 ±9.52 mm to 34.25 ±13.22 mm (Fig-3). The mean values of other three parameters i.e. Tor (Fig-4), Tsk (Fig-5) and HR (Fig-6) increased gradually in both the sets of experiments. Mean Tor in general and HR at 45th and 60th minute during HEx were comparatively lower in 1st set with SSP than in 2nd set without SSP.

DISCUSSION

The present study shows that by SSP subjects could maintain core temperature in hot environment with a relatively lesser thirst sensation and sweating. HR which is a very important indicator of heat strain has not shown any significant difference during HEx between two sets (Fig-6). Heat stress related discomfort occurs when the body cannot cool itself enough to maintain a normal core temperature (37°C). When it is very hot, there is an increased risk of heat stress related disorders. Symptoms of heat stress disorders, like tiredness, lethargy, headache, dizziness, muscle cramps, increased thirst, lesser urination gradually appears. Visible signs of heat strain are pale skin and excessive sweating. Subjects of this study have not shown any of those symptoms prominently other than the increased thirst and sweating due to HEx. Both magnitude of thirst and sweating are comparatively lower by SSP during HEx indicating positive effect of SSP.

Possible mechanism of heat stress management through SSP

Physiological mechanism of heat stress management has two-pronged strategies. One is peripheral vasodilatation for better heat dissipation through the skin. The other one is the sweating mechanism which sets in during heat stress in very hot and humid condition. In extreme hot-humid condition both the mechanisms operate and there is a reduction of blood volume due to loss of body water. In this situation, the cardiovascular system tries to compensate for this by increasing the blood flow by maintaining cardiac output and increasing the heart rate.

In this study, on HEx, in both with SSP as well as without SSP, the usual pattern of changes as happens in heat stress have happened in Tor i.e. a gradual increase due to heat load (Fig-4); in Tsk i.e. a gradual increase due to peripheral vasodilation to dissipate heat (Fig-5) and also in HR, i.e. the gradual increase in HR due to heat strain (Fig-6). But, in the 1st set with SSP mean Tor values is comparatively lower during HEx than that of 2nd set without SSP which indicates a tendency of a better core temperature control by SSP. Similarly, mean Tsk showing comparatively lower value with SSP than without its practice towards the end of HEx indicates relatively lesser requirement of heat dissipation by vasodilation. From the meteorological and physiological data of this study it appears that the heat stress as such is in a moderate zone, where subjects have better control over the situation. Still, in the 1st set, they have lesser thirst sensation by SSP as compared to that of 2nd set without SSP (Fig-3). Thirst sensation is a signal to indicate the need of water. Water is essential to maintain body fluid homeostasis. Thirst may be felt due to deficits in either intracellular or extracellular fluid volume. During the thirst sensation increase in plasma osmolality, decrease in blood volume, decrease in blood pressure, increase in angiotensin II, dryness of mouth and throat occur. Osmoreceptors act to develop an urge to drink due to dryness of mouth and throat [15]. SSP helps to increase saliva secretion which is continuously formed and coat the tongue and subsequently evaporate. This evaporation, with the use of lean heat from inner aspects of mouth brings the feeling of coolness in the mouth. There is evidence that increased hydration is associated with greater salivary output [16]. The clinical assessment of oral dryness is a significant predictor of salivary gland hypo function [17]. Another important finding is that sweating response is also comparatively lesser in the 1st set with SSP (Fig-2). It may be during SSP vasopressin secretion increases in response to dehydration and it causes the kidneys to excrete less water. The net effect is an increased amount of water in the blood. The overall picture is that in heat stress condition by SSP subjects are in a better condition to cope with the heat stress by regulated fluid loss in one hand with better control over the thirst sensation on the other hand.

SSP with reference to physiology of pranayama practice and temperature regulation

It was found that *Tibetan-tum-mo* yoga practitioners, who had been practising the pranayama type of breath control exercises for several hours a day regularly for many years, had the ability to raise their skin temperature by 8.3ºC [7]. Another study shows that even common men (soldiers) who are not accomplished yogis could maintain core temperature in a better way as compared to the control group. Even non-shivering thermogenesis as mechanism was postulated to this which is unusual in normal human being [8]. EEG studies on SSP in normal condition without HEx reported promotion of relaxation and calmness of the subject as indicated by brain waves representing these psycho-physiological features [18]. Several studies have reported that yogic practices influence the autonomic nervous system (ANS) bringing about relatively parasympathetic dominance [2,19]. ANS control is mostly executed through hypothalamus, which is responsible for temperature regulation [15]. A study on pranayama with alternative nostril breathing has shown that it influences the parasympathetic nervous system, which helps to decrease pulse rate, respiratory rate and diastolic pressure significantly [20]. Thus, pranayama slows down metabolic rate and anabolic mechanism is enhanced with the progress of relaxation. Regular practice of pranayama influences the release of neurotransmitters like GABA (gamma-amino butyric acid), endorphin and serotonin [21].

Mechanism of thirst sensation and its suppression by SSP

It has been found that human beings become thirsty and drink even before body fluid deficit develops when there is free access to water. This happens due to oropharyngeal cues. This provides evidence of anticipatory thirst sensation and urge to drink water [22]. Oropharyngeal receptors take an important role in thirst perception. They not only contribute to the sensation of thirst, but also to the control of vasopressin secretion [23]. Although only oropharyngeal factors alone may not be cause for the usual reason to stop drinking in most species, still it has been described to play a role in the initiation and maintenance of drinking as well as to have a role in the termination of drinking [24,25]. It has also been indicated that oropharyngeal stimulation brings about the initial decrease in thirst, without abolishing it [24]. In a more recent review, it has been concluded that oropharyngeal afferent nerve helps in the suppression of thirst [26]. It may be acting through midline thalamic neucli to the higher centers to modulate thirst sensation in one hand. On the other hand, it may control sweating response through hypothalamus. Thus, the cool sensation developed by SSP in the oral cavity may help in the management of body fluid as well as thirst in the HEx level as observed in this study.

Heat stress management by SSP and future possibilities

One of the most remarkable features of homoeothermic animals is to regulate their body temperature according to the environment, their ability to sense the changing internal needs and then generate specific behavioral and physiological responses that restore internal balance through homeostasis. Normal human being also has this ability but that also within certain limits, which varies from persons living in severe cold environment like arctic environment and subzero temperature of Kalahari Desert, where Australian aborigines lives to tropical and subtropical climates of different continents where vast human habitations are being observed. This study shows that subjects in the 1st set with SSP practice have felt less thirst sensation, and also sweated less, indicating better fluid balance. On the other side, when same subjects did not practice SSP, sweated more along with greater thirst sensation indicating greater heat strain, though it has no statistically significant impact on heart rate. The interesting point to notice is that in both the sets of experiments, subjects are the same yoga practitioners that is why they could feel the actual effect of SSP and differentiate between two conditions i.e. heat stress with SSP and heat stress without SSP. The exposure time in hot environment in this study was one hour only. Heat tolerance level of the subjects could have been different if the exposure time and /or heat stress level increased. Again, even if in greater duration and intensity of heat stress up to some duration and / or intensity, initially SSP could help to preserve the physiological reserves for heat stress management in a better way so that overall tolerance to heat stress increases to a certain extent. It can be surmised that within the intensity of heat stress and duration of exposure time in this study SSP have the potential to help an individual to combat heat stress. Further in-depth studies are required in this regard.

CONCLUSION

SSP help to reduce thirst sensation and fluid loss from the body within the heat stress level as observed in this study. Both subjective and objective evidences obtained from the present study give indications that the assumptions of the yoga masters on SSP about thirst and heat stress management as stated in ancient yoga texts are also scientifically true. This is the first scientific study on heat stress management on SSP. SSP may be used as a strategy for heat stress management within moderate heat stress level. In prolonged and/or greater intensity of heat stress, SSP may increase the tolerance to heat stress up to a certain level by its potential to preserve the physiological reserve for heat stress management at initial stage of heat stress itself, which may help to combat greater heat stress in the long run. Even, it may have potential application in inadvertent situations with water scarcity, which may be for short duration but for temporary relief to a person. Further in-depth scientific studies in this regard are required.

Funding source

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Ethical Consideration

Approval of the institutional ethical committee for human trial for this study was obtained. This has been mentioned in the 'Methods and Material' section of the manuscript.

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A B

Fig. 1

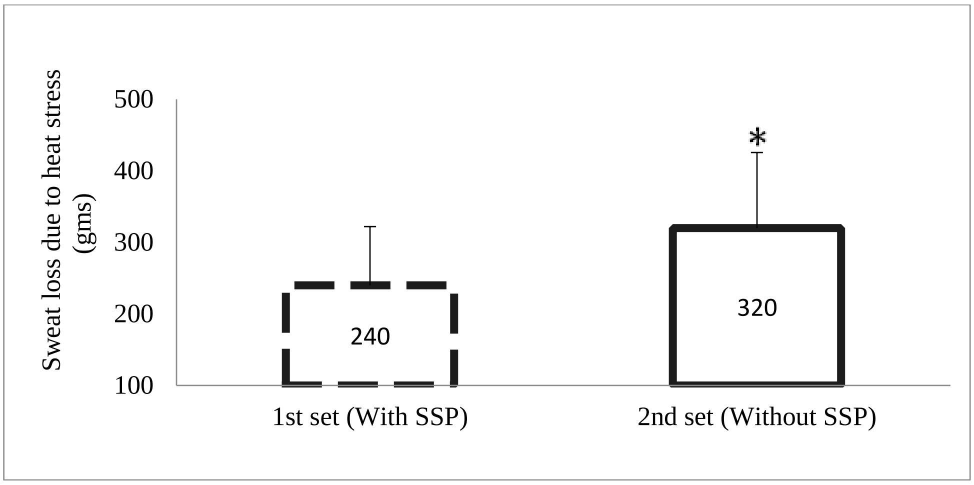

Fig.2: Comparison of sweat loss (Means ±SD) between 1st set and 2nd set. It shows that sweat loss due to heat stress was significantly lower in the 1st set with SSP practice than in the 2nd set when SSP not practiced. * P < 0.05.

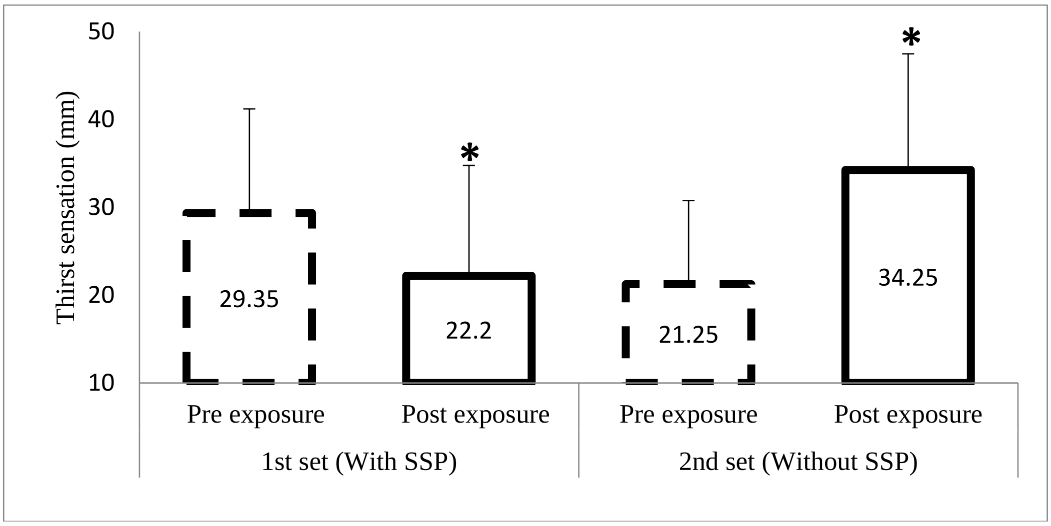

Fig. 3: Comparison of thirst sensation (Means ±SD) between pre & post HEx of 1st set and 2nd set. It shows that on HEx in the 1st set with SSP thirst sensation significantly reduced compared to pre-exposure period. But in the 2nd set without practicing SSP it significantly increased in the post exposure period. * P < 0.05.

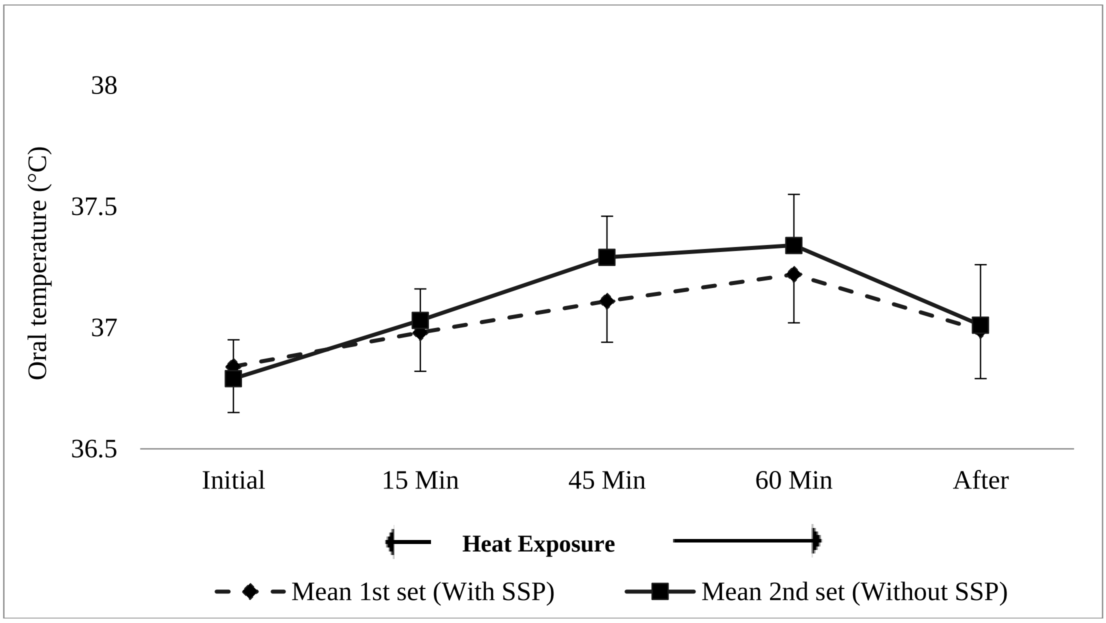

Fig.4: Comparison of Tor (Means ± SD) between 1st set and 2nd set. The graph shows that mean value Tor has gradually increased in both with and without SSP practice on HEx and it is comparatively lower throughout the period of HEx in the 1st set with SSP practice compared to 2nd set when SSP not practiced.

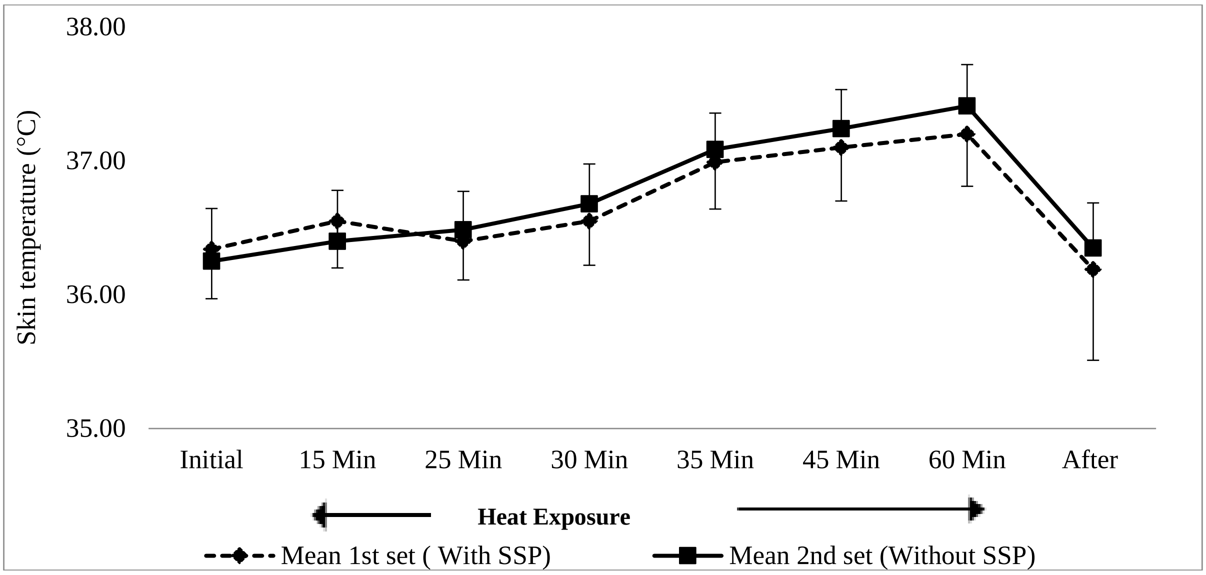

Fig.5: Comparison of Tsk (Means ± SD) between 1st set and 2nd set. The graph shows that mean value of Tsk has increased gradually in both with and without SSP. It has remained almost closer to each other throughout HEx except being slightly lower in the 1st set with SSP.

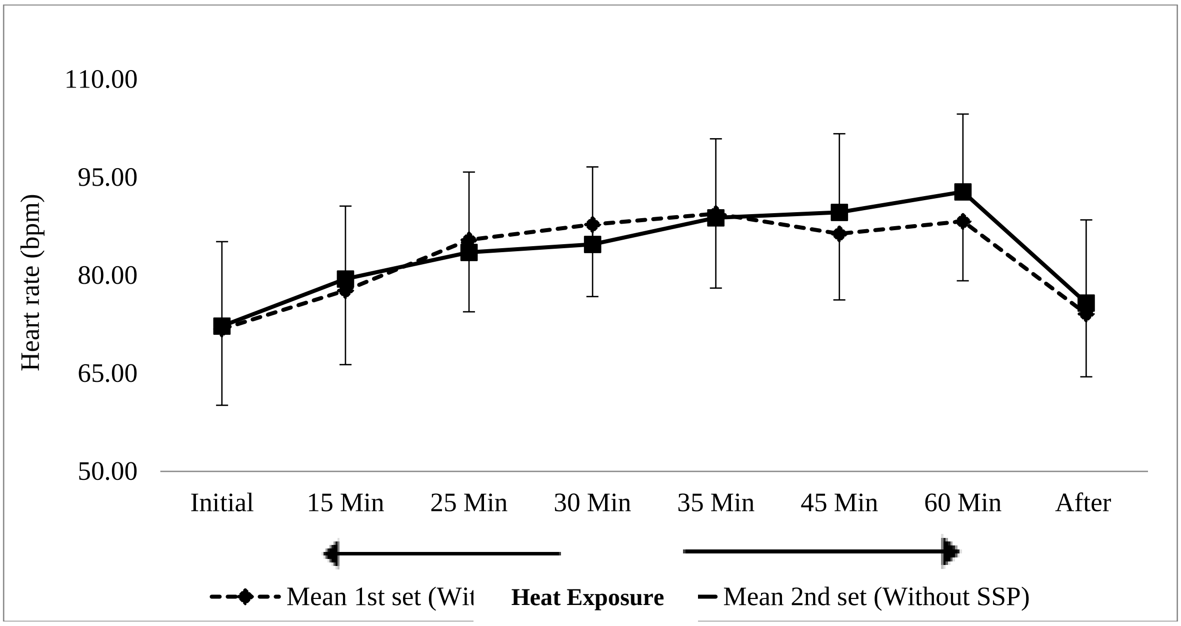

Fig.6: Comparison of HR (Means ±SD) between 1st set and 2nd set. It shows that mean HR, representing heat strain, has increased gradually on HEx both with and without SSP practice. In the 1st set with SSP practice it is relatively lower towards the end of HEx as compared to that of 2nd set without SSP practice.