Defence Life Science Journal, Vol. 4, No. 3, July 2019, pp. 163-169, DOI : 10.14429/dlsj.4.14275

Yoga Intervention as a Potential Countermeasure for Polar T_3 Syndrome

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ABSTRACT

Polar T_3 syndrome is a common ailment for polar sojourners. It is characterised by abnormal fluctuations of thyroid hormones during extended polar winter. A randomised controlled study was conducted on 14 winter expedition members of Indian Scientific Expedition (2016) to Antarctica by introducing customised yoga module. Blood samples were collected during January to October, 2016 at different intervals for the estimation of total thyroxine (TT_4), total triiodothyronine (TT_3), thyroid stimulating hormone and noradrenaline (NA) by ELISA. In October yoga group showed significant ($p = 0.04$) higher TT_3 values (2.1 ng/ml ± 0.9; mean ± SD) as compared to the control (0.7 ng/ml ± 0.6). In October a significant difference ($p=0.0085$) was observed between yoga and control group for NA values (47.0 pg/ml ± 22.0 and 107 pg/ml ± 46.0). Thyroid response of control group at the end of the study revealed presence of polar T_3 syndrome in control group. Results indicate that regular yoga practice helped mitigating polar T_3 syndrome.

Keywords: Antarctica; Thyroid hormones; Isolation; Noradrenaline; Extreme environments; Yoga.

NOMENCLATURE

TT_3	Total Triiodothyronine
TT_4	Total Thyroxine
TSH	Thyroid stimulating hormone
NA	Nor-adrenaline
RM-ANOVA	Repeated measures analysis of variance
BW	Body weight
SBP	Systolic blood pressure
DBP	Diastolic blood pressure
ISEA	Indian scientific expedition to Antarctica
BS	Bharati Station (Indian research base in Antarctica)

1. INTRODUCTION

Every year different countries conduct their Antarctic expeditions to explore the continent for different scientific aspects like Geosciences, Life Sciences, Social Sciences, Meteorology, and Physical Sciences[1]. Antarctica is an ideal environment for cold and long-term confinement related studies on humans as their diet, routine, environment and lodging can be easily monitored. In Antarctica, research bases are generally designed as such to minimise space and conserve indoor heat leaving working area and living modules very close. This raises limited movement and monotonous routine work. In addition, same team members are also involved in work and leisure which creates boredom and inter-personal conflicts. These stressors affect wide array of psychological and physiological well being of expedition members during long-term stay or wintering-over in Antarctica[2–7].Geographical and social isolation, extreme cold, blizzards, crevasses, unusual photoperiod (resulting sleep disturbances), exposure to perilous situation and high workload add to the misery. Apart from performing their professional duties team members are also required to contribute in outdoor and indoor station community works. Every team member is exposed to extreme weather of Antarctica on an average 7 h - 8 h in austral summers and 4 h - 5 h in austral winters; remaining time of the day spent inside the Bharthi station having inside temperature maintained at 25 ± 2 °C (Fig. 1).

Many studies revealed the importance of thyroid hormones in psycho-physiological well-being[5,8]. It has been reported that decreased levels of Triiodothyronine (T_3) and Thyroxine (T_4) and increase in TSH of winter crew members in Antarctica lead to cognitive impairment, mood disturbances and depression collectively described as Polar T_3 Syndrome[2-7]. Since its prevalence is restricted to polar sojourners only few studies have addressed the issue. The normal reference range of serum total triiodothyronine (TT_3) in healthy individuals under normal environment conditions ranges from 0.9 ng/ml - 2.15 ng/ml[11]. Role of thyroid hormones especially under chronic cold exposure have been reported. Thyroid hormones seem to help

Received : 13 March 2019, Revised : 10 June 2019
Accepted : 17 June 2019, Online published : 15 July 2019

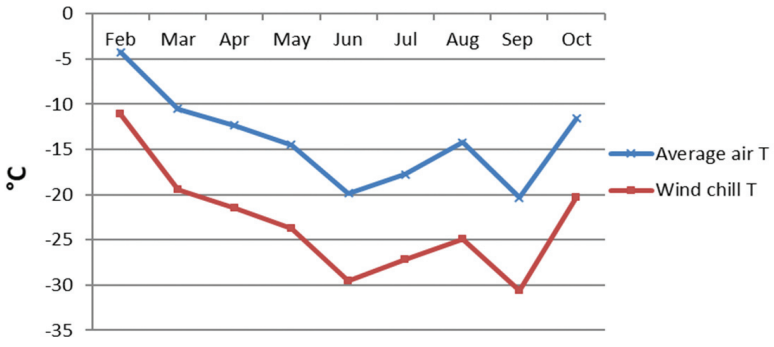


Figure 1. Mean monthly air and wind-chill temperature at Bharati Research Base, Antarctica.

Table 1. Features of Bharati Indian research base

Location within Antarctic circle	69° 24.41' S, 76° 11.72' E[30]
Altitude	35 m (approximate)[30]
Mean outside temperature (during the study)	-13.9°C
Winter duration	From late February to early December
Photoperiod	Polar day and polar night
Surrounding bases	None
Animals	None during winter
Plants	None
Total number of winter members	23
Lodging	Single room
Food supplies	Cereal, frozen meat, scarcity of vegetables and fruits from May to December
Telecommunication	Telephone and internet facility available
Amusements	Library, Table-tennis, laptops with internet

in cold acclimatisation by increasing the metabolic exothermic reactions and switching of slow-twitch to fast-twitch skeletal muscle fibres[6,12]. Nor-adrenaline (NA) has been reported to be playing some role in acclimatisation to acute cold in humans[13]. Serum NA increases following cold exposure[6]. Thyroxine supplementation has been suggested to improve symptoms of polar T_3 syndrome[14].

Here, we have tried to know whether practicing yoga during extended Antarctic residence can help preventing unusual dwindling of thyroid hormones thus helping managing the syndrome. There are many studies on beneficial effects of yoga[15-25] and it has been reported helpful in imparting cold tolerance also[26]. Yoga induces decreased peripheral demand of thyroid hormones[27] and help in management of hypothyroidism[28,29] but it's efficacy under Antarctic environment is not known. Therefore, it may be hypothesised that yogic intervention for winter members in Antarctica may help mitigating polar T_3 Syndrome.

2. MATERIALS AND METHODS

2.1 Study Participants

Twenty-three medically healthy males winter team of 35th Indian Scientific Expedition to Antarctica (2015-16) posted in 'Bharati' Indian Research Base in Antarctica participated in the study. Features of Bharti research station is given in Table 1. They reached Bharati by flight from Mumbai, India via Cape Town, South Africa as transit. Written consent was obtained from each participant after informing details of the study and protocols approved by Ethics' committee of the Institute (IEC/DIPAS/C-10/2). Participants were divided in two groups' yoga (n=11) and control (n=8) (without yogic intervention) randomly based on their willingness to practice yoga during stay in Antarctica (Fig. 2). Data of participants on regular medications which may adversely affect the outcome of the study were excluded. Basic health parameters of the participants are as given in Table 2.

2.2 Sample Collection

The study was conducted during the months of January to October, 2016 in BS, Indian Research Base, Antarctica. Participants' body weight was measured using digital bench platform scale with a capacity of 120 kg and an accuracy of ± 0.5 kg. Blood pressure of participants was recorded by using a mercury sphygmomanometer following 5 minutes rest. Blood collection was done at four time points: baseline in early January (i.e. before introducing yoga sessions to the participants), two times during Antarctic winter (May and August) and at the end of yoga intervention (October).

2.3 Estimation of Hormones

For the estimation of serum TT_3, TT_4, TSH and NA, 12 hour fasting blood was collected from antecubital vein between 8:00 hrs and 9:00 hrs before breakfast. Blood was collected in clot activating Vacuette® tubes (Ref. 454092). After collection, the tubes were spin-down and serum was collected in polypropylene tubes. Aliquots of collected serum in polypropylene tubes are then stored at -40°C in BS's laboratory until further analysis in the DIPAS's laboratory. Estimation of hormones was made using commercially available ELISA kits for Total Triiodothyronine (TT_3, Cat. No. T3225T), Total Thyroxine (TT_4, Cat. No. T4224T), Thyroid Stimulating Hormone (TSH, Cat. No. TS3227T) procured from CALBIOTECH, USA and NA (NE, Cat. No. BA E-5600) product of LDN 3-CAT, Germany. Standards and samples were run in duplicate.

2.4 Yoga Intervention

After collection of baseline data, customised yogic module for Antarctic expedition members was imparted for ten months daily for one hour in the morning by a certified yoga practitioner (first author of this article). It consisted of sukshma vyayama, asanas, pranayama and guided meditation (Table 3). Details of the yoga package imparted can be found in our previous work[31].

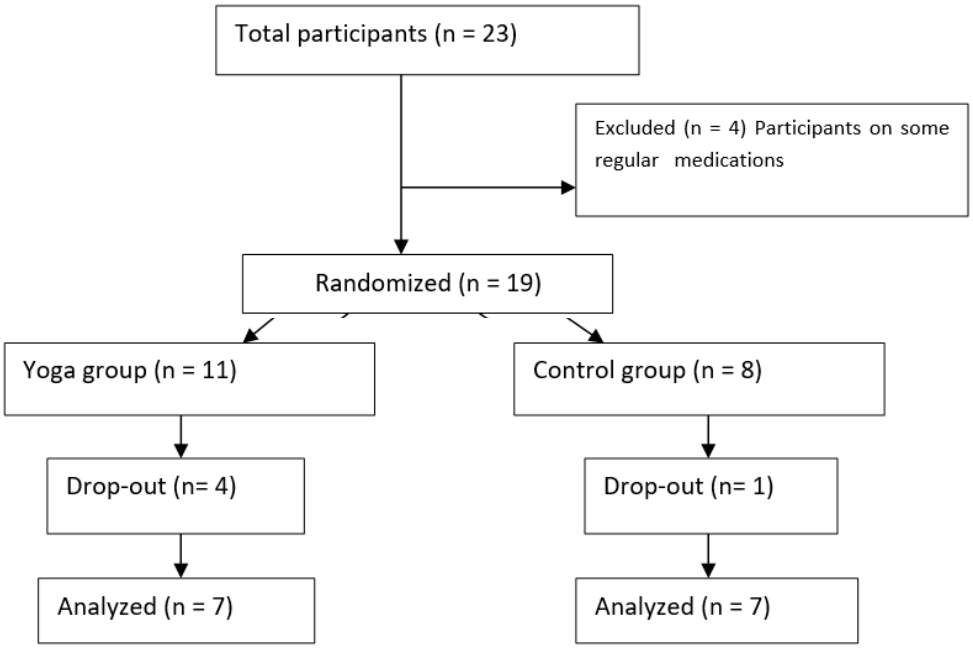


Figure 2. Illustrates schematic representation of participants' distribution. Four participants dropped out from yoga group as they lost interest in yoga; one participant withdrew from control group as he was unwilling to provide blood sample for the study.

Table 2. Basic health parameters of participants. They did not differ between both the groups significantly.

Parameter	Yoga (Mean ± SD)	Control (Mean ± SD)
Age (years)	40.0 ± 12.9	38.7 ± 9.0
Weight (kg)	72.7 ± 9.9	71.1 ± 16.6
Height (cm)	169.0 ± 4.2	169.0 ± 7.9
Systolic BP (mmHg)	122.3 ± 7.6	118.3 ± 8.1
Diastolic BP (mmHg)	82.3 ± 7.1	79.4 ± 6.7

Table 3. TT4, TT3, TSH and NA levels of both the groups at different time-points. Data are presented as mean ± SD.

Parameter		January	May	August	October
TT_4 (µg/dl)	Yoga	3.8 ± 1.0	4.5 ± 1.3	2.5 ± 1.0	3.0 ± 0.6
	Control	3.4 ± 1.1	3.2 ± 0.6	3.0 ± 0.6	3.0 ± 0.7
TT_3 (ng/ml)	Yoga	3.4 ± 0.8	3.6 ± 1.0	2.0 ± 1.1	2.1 ± 0.9
	Control	3.8 ± 0.6	2.4 ± 1.0	1.3 ± 0.5	0.7 ± 0.6
TSH (µIU/ml)	Yoga	3.3 ± 2.9	2.9 ± 1.9	5.6 ± 4.0	2.4 ± 1.6
	Control	3.2 ± 2.5	3.2 ± 2.0	3.4 ± 0.8	3.8 ± 1.9
NA (pg/ml)	Yoga	46.4 ± 22	43.7 ± 11	67.0 ± 27.3	47.0 ± 26.2
	Control	52.5 ± 12.7	59.2 ± 26.4	73.5 ± 47.4	107.2 ± 46.0

Values have been approximated to one decimal.

2.5 Statistical Analysis

GraphPad Prism (Version 5.00) software was used for statistical analysis and IBM SPSS version 21.0 for making box plots. Two-way Repeated Measures Analysis of Variance (RM-ANOVA, mixed model) was used to assess difference between means of inter- and intra group followed by Bonferroni post-tests. Changes with $p < 0.05$ were considered statistically significant.

3. RESULTS

Following results were obtained for finding if yoga can help managing the syndrome.

3.1 Body Weight

In yoga group, from January to October a decrease of 5.1 per cent and in control group a decrease of 0.6 per cent was found as shown in Fig. 3(a).

3.2 Systolic Blood Pressure

An insignificant decrease of 2.6 per cent in yoga group and 1.2 per cent in control group was recorded when January and October's data is compared as shown in Fig. 3(b**).**

3.3 Diastolic Blood Pressure

Almost no comparable changes were found in January and October months from both the groups as shown in Fig. 3(c).

3.4 Serum Total Thyroxine

There was 17.8 per cent increase from January to May in yoga group followed by 44.4 per cent decrease in August. It further increased 18.9 per cent in the month of October in yoga group. There is statistical significant difference ($p = 0.02$) in TT_4 levels in both the groups in May. Control group showed consistent decrease of 12.3 per cent up to August with no further change in the month of October as shown in Fig. 4(a) and Table 3.

3.5 Serum Total Triiodothyronine

An increase of 4.2 per cent in May from baseline was observed in yoga group; thereafter a decrease of 44.3 per cent in August. Then an increase of 7.1 per cent in the month of October which is statistically significant ($p = 0.04$) when compared with control's October TT_3 values. Control group showed steady decrease up to 80.7 per cent from January and till the end of the study as shown in Fig. 4(b) and Table 3.

3.6 Serum Thyroid Stimulating Hormone

In yoga group an initial decrease of 11.5 per cent from January to May was seen followed by

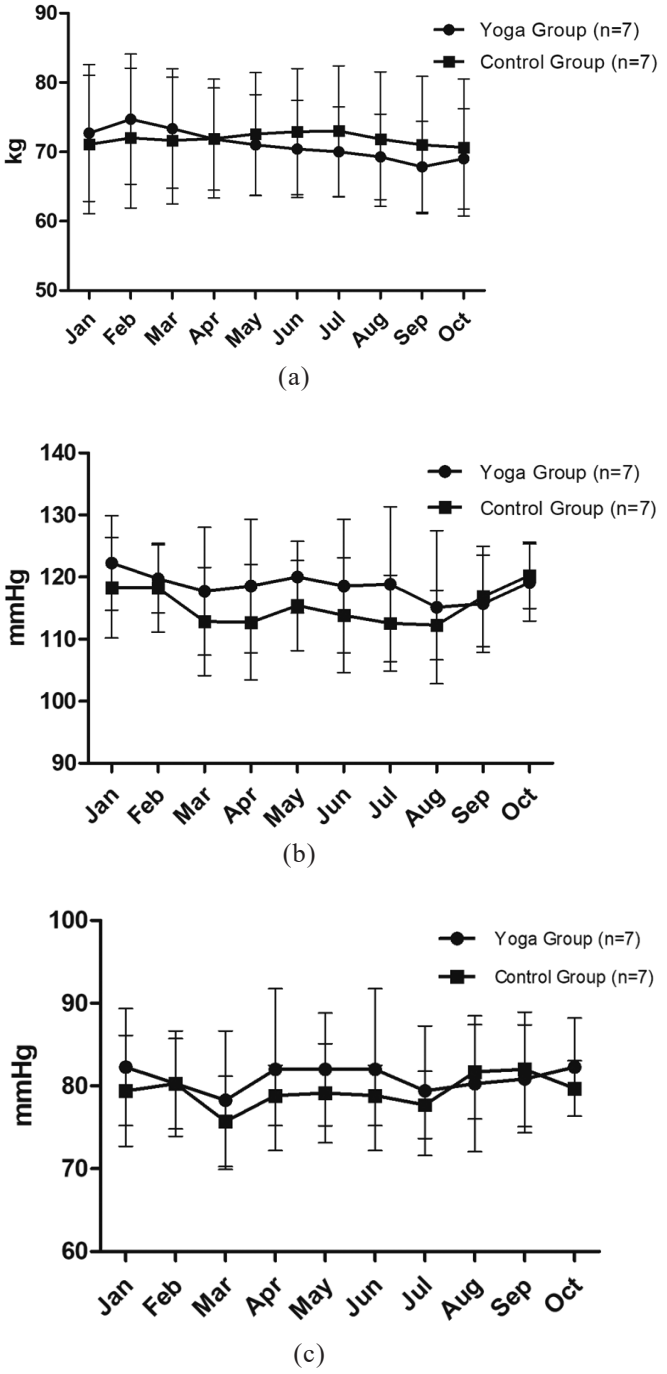


Figure 3. Mean value changes in (a) body weight, (b) systolic blood pressures at different time points in yoga and control groups (c) diastolic blood pressure. Error bars represent standard deviation.

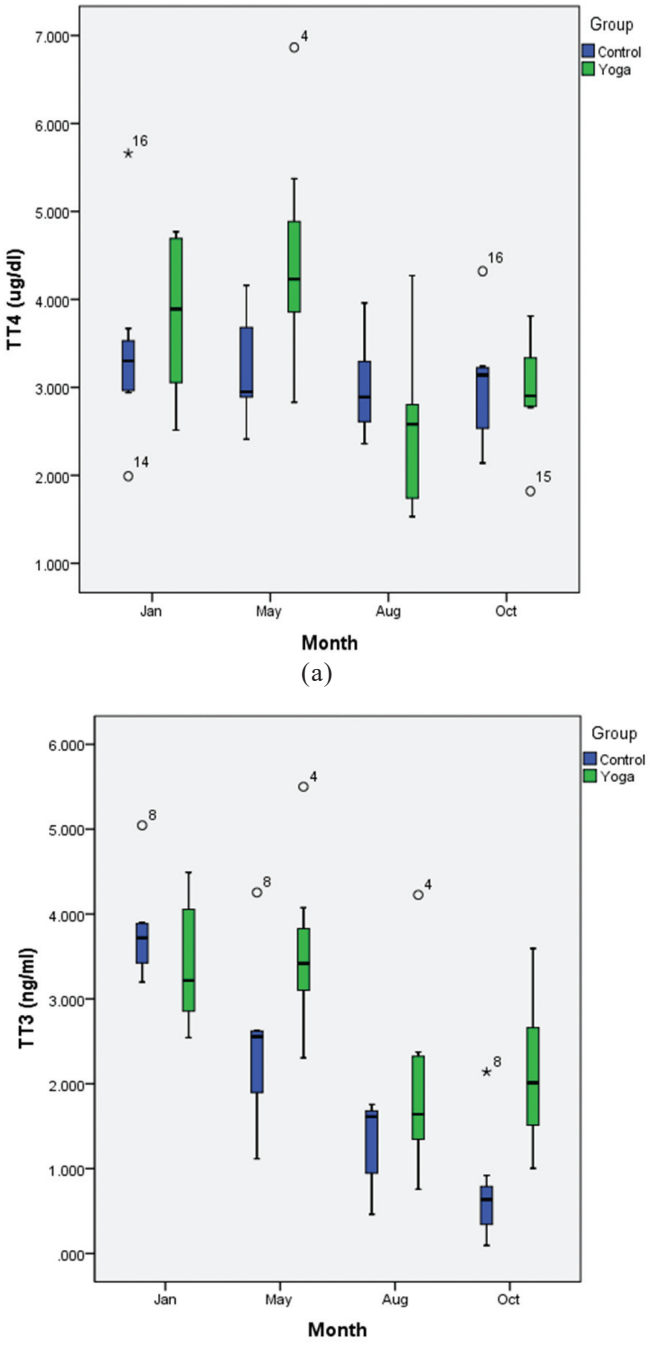
sharp increase of 91.2 per cent in August and decrease of 56.0 per cent in October. A total increase of 16.9 per cent was found in control group from January to October as shown in Fig. 4(c) and Table 3.

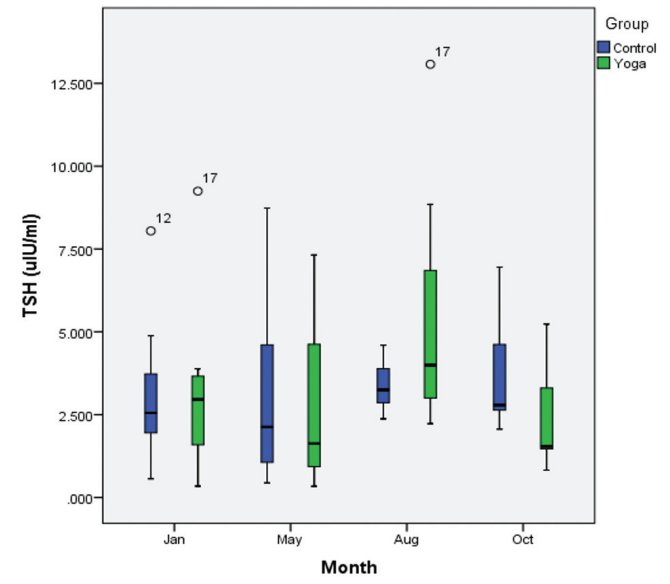
3.7 Serum Noradrenaline

In control group showed increase in all the time-points. Yoga group shows a 5.7 per cent decrease in May when compared with baseline serum value; 53.3 per cent increase in August then finally 29.9 per cent decrease in October. A statistically significant difference (p=0.0085) was observed between yoga and control group in the month of October. (Fig. 4(d) and Table 3.

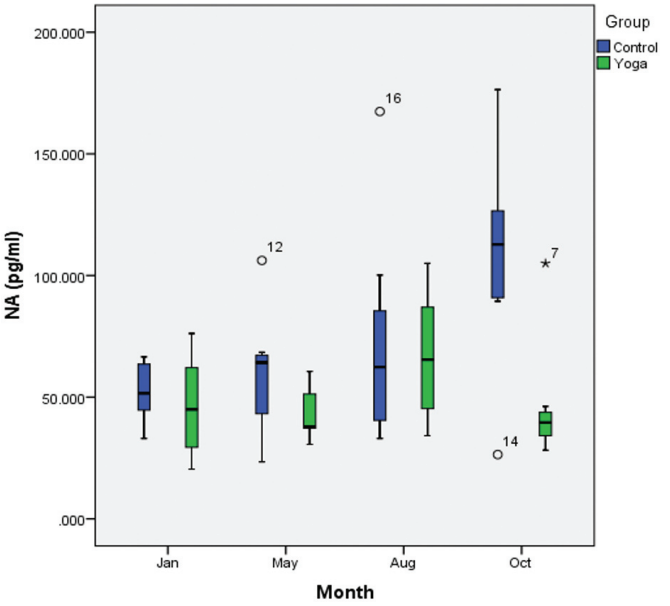
4. DISCUSSIONS

In control group steady decrease in serum TT_3, TT_4 and increase in TSH throughout the study suggest their thyroid status from euthyroid to subclinical hypothyroidism indicating polar T_3 syndrome in them as reported by other similar studies[2,6,9]. However in yoga group there is an initial increase in serum TT_3 and TT_4 in May month may be because yoga practice is known to induce hypo-metabolic state thereby decreased peripheral requirement of thyroid hormones[27,31]. Further decrease in weather temperature (Fig. 1) from the month of May peripheral





(c)



(d)

Figure 4. Box-plots of (a) TT_4, (b) TT_3, (c) TSH and (d) NA data at different time points of the study. Statistical significance set at $p < 0.05$.

demand of thyroid hormones increased to bear extreme cold stress thus decreasing TT_3 and TT_4 in both groups in August. As weather temperature increased in the month of September, TT_3 and TT_4 serum levels recovered in yoga group unlike control group in which consistent decrease in thyroid hormones was observed supporting role of yoga in maintaining physiologic levels of thyroid hormones. Consistent decrease of serum TT_3 and TT_4 in control group may be attributed to "tiring" of thyroid gland that cannot keep up the physiologic equilibrium of supply and demand. TSH levels fluctuated according to TT_3 hormone as TSH is controlled by TT_3 hormone in a negative feedback loop. In control group as thyroid hormones dwindle down with time spent in Antarctica, compensatory increase in serum nor-adrenaline was found[8]. Similarly, in yoga group, serum nor-adrenaline changed to compensate serum thyroid values. The yoga module consisted of surya namasakara or sun-salutation and asanas which increases activity of skeletal muscles thus may be helping in adaptive thermogenesis. Few studies have reported no noticeable changes in body weight during extended Antarctic residence[3,33]. One study has reported increase in body weight during winter[34]. Our study has found consistent decrease in body weight during the stay in yoga group. In control group similar trend was observed except in May in which there is a marginal increase. Decrease in body weight in both the groups is may be because during Antarctic winters many food items get exhausted causing reduced variety and options; however the decrease is statistically insignificant in both the groups. There were no particular differences in blood pressure in both the groups during the study.

The major limitation in this study is the sample size. Our sample size in this study was the total number of winter team members of 35th ISEA assigned for Bharthi. Since Antarctic expeditions are costly affairs and risky, a statistically healthy sample size for experiments is rarely achieved.

5. CONCLUSIONS

In this study an attempt has been made to explore possible role of yoga in countering polar T_3 syndrome and long-term confinement. The key finding is that TT_3 values in control group were progressively getting decreased during extended Antarctic residence however yoga group's values "resisted" the change. Results are indicating that yoga was helpful in countering abnormal fluctuations in thyroid hormones. It might prove useful for studying thyroid functions in extreme environments and long-term confinement like planetary outposts or space.

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ACKNOWLEDGEMENTS

- Authors express their sincere thanks and gratitude to 35th ISEA expedition members for participation in the study.
- Authors are grateful to Director, DIPAS, Defence R&D Organisation for providing support and necessary funds to conduct the study.
- Authors are thankful to NCPOR for approving and providing the essential logistics' support for conduct the study.
- Authors are thankful to India Meteorological Department for providing weather data around BS, Antarctica.

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Ms. Shashi Bala Singh was a former Director at DIPAS and former DGLS at DRDO. She has co-authored more than 100 publication with diverse scientific aspects.
She founded the idea of the study, approved and monitored the study.

Mr. Ragavendra Samy was working as an Assistant Professor at SVYASA, Bangalore.
He contributed in designing of yoga package for Antarctic expedition members.

Ms. Lilly Ganju is working as Scientist 'G' and head of Immuno-modulation division at DIPAS. She has vast experience in representing DIPAS and its' participation in ISEAs.
She was involved in getting funding and approval of the study.