TECHNOLOGY FOCUS
टैक्नोलॉजी फोकस

An In-house S&T Bulletin of DRDO

www.drdo.gov.in

Vol 28 | Issue 4 | August 2020 | ISSN No. 0971-4413

ENVIRONMENTAL PHYSIOLOGY, METABOLISM, OMICS & HUMAN FACTOR RESEARCH

Technology Focus focuses on the technological achievements in the organization covering the products, processes and technologies.

August 2020
Vol. 28 | Issue 4
ISSN No. 0971-4413

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From the Desk of Guest Editor

Defence Institute of Physiology and Allied Sciences (DIPAS), one of the life sciences laboratories under DRDO, is a premier institute in the country involved in research for health and performance optimization of Indian soldiers. DIPAS was officially instituted on 20 September 1962 at Defence Science Laboratory (now Laser Science & Technology Centre) at Metcalfe House, Delhi. For a short period from 1962 to 1968, it was located in the Physiology Department of Madras Medical College, Chennai. In 1968, it was subsequently relocated at the Army Base Hospital, Delhi Cantonment.

In the year 1993, the Institute shifted to its present permanent premises at Lucknow Road, Timarpur, Delhi. Since then DIPAS has consistently flourished with modern infrastructure for Physiological, Biochemical, Nutritional, Biomedical & Molecular (Proteomics & Genomics) research to provide holistic health and enhance performance of our soldiers guarding our borders under extreme climatic conditions.

DIPAS has specialization in life sciences research using man to molecule approach. Research involves use of in vitro, in vivo experimental models including direct measurements and data collection from soldiers under simulated as well as under actual conditions of their deployment. Institute also has specialization in human factor research and ergonomics and is providing inputs for design of weapons and different platforms for better man-machine interface.

This issue of *Technology Focus* highlights some of the S&T achievements of DIPAS benefiting primarily our Armed Forces and as a spin-off civilians.

Bhuvnesh Kumar
OS & Director, DIPAS

ENVIRONMENTAL PHYSIOLOGY, METABOLISM, OMICS & HUMAN FACTOR RESEARCH

Advanced weapon systems and well trained 'fighting fit soldiers' are key elements of successful Armed Forces. Indian soldiers are deployed under different climatic conditions like cold, high mountains, hot desert, hot humid coastal regions and jungles, etc., to guard our boundaries. Besides, they also help in rescue/ relief operations at the time of natural calamities. Physical and cognitive efficiency of soldiers under these challenging conditions are affected due to physiological and metabolic adjustments. Basic and applied research by Defence Institute of Physiology and Allied Sciences (DIPAS) in actual field conditions as well as in the lab have helped in enhancing efficiency of our jawans and their survivability under hostile climatic conditions. Many of the recommendations made by DIPAS to mitigate physical and psychological problems faced by our troops in extremely difficult and adverse climatic conditions have been implemented by our Armed Forces.

Some notable contributions and technologies by DIPAS have been highlighted here.

Technologies for Acclimatization, Rapid Induction & Sustaining Health at HA

High altitude (HA), terrestrial height more than 2700 m above mean sea level, is characterized by hypoxic environment, sub-zero temperature and intense UV radiation. All these have adverse effect on efficiency and cognitive functions of a human being. About 30 to 40 per cent lowlanders visiting high altitude develop acute mountain sickness characterized by headache, shortness of breath, nausea within few hours of ascent. People may also endure debilitating frostbite or develop life threatening diseases like high altitude pulmonary edema (HAPE) and cerebral edema (HACE), which need evacuation and medical treatment. Acute Mountain Sickness (AMS) may be because of sudden change in altitudes. Proper acclimatization and preventive medications may led in reduction of medical problems related to HA.

Several physiological changes like hyperventilation, increased erythropoiesis to increase oxygen carrying capacity take place in acclimatization. DIPAS has developed acclimatization schedule (staging of acclimatization) for the induction of Indian troops at HA based on detailed longitudinal studies using physiological, psychological, biochemical, and hormonal profile assessment of soldiers under HA conditions. This has helped army in significant reduction of altitude sickness among troops.

At present total duration of acclimatization for deployment at heights more than 4500 m is of 14 days. Strategies like induction of troops from moderate attitude and Intermittent Hypoxia Exposure (IHE) at sea level, have been evaluated for rapid induction of troops in case of any emergency. For preventing ill effects of rapid induction, oxygenated shelters are being used; it is well established that one per cent increase in oxygen is equivalent to reduction of 1000 ft altitude. Use of solar energy for heating, power generation and oxygen generators, to increase oxygen level, have also been successfully demonstrated.

IHE at Plain as a Modality for Rapid Deployment

Exposure to normobaric hypoxia (12 per cent FiO_2 created by increasing nitrogen levels in the room), four hours per day for a duration of four days at sea level, helps in stabilization of hypoxia inducible factor, which is a triggering factor for initiation of acclimatization

Normobaric Hypoxia Chamber for IHE: Inside view

response of the body, i.e., increase in hemoglobin content in the body to facilitate oxygen carrying capacity through erythropoiesis. This exposure protocol has been found effective in saving two days of acclimatization with significant reduction in cases of AMS. Both, incidence as well as severity of AMS symptoms, have reduced significantly in case of soldiers inducted after IHE at sea level. Use of prophylactic drugs like acetazolamide and herbal agents, found effective in pre-clinical studies carried out by DIPAS, would further reduce induction time period. Normobaric hypoxia chambers with capacity of 50 persons have been installed at N Area, and Begdugi, near Baghdogra for technology demonstration.

Prognostic & Diagnostic Markers/ Devices & Therapeutics for HA Maladies

Brain Natriuretic Peptide as Bio-marker of Hypoxia Susceptibility

In spite of following strict acclimatization schedule some personnel develop HAPE. Existence of endothelial dysfunction and chronic hypoxia mediated vascular remodeling leads to hypoxia susceptibility. Assessment of hemodynamic response to hypoxia is the gold standard test followed globally to predict HAPE susceptibility. However, it requires specialist to conduct the hypoxia tolerance test. Prospective and retrospective studies done by on HAPE susceptible by DIPAS have shown that brain natriuretic peptide (BNP) levels correlate with endothelial function and is equally capable to predict hypoxia susceptibility among healthy individuals. BNP<15 pg/ml indicates hypoxia resistance while BNP>41 pg/ml indicates HAPE susceptibility. Ease of testing makes it a potential biomarker for HA maladies. Screening of troops at sea level may therefore be a useful step towards personalized risk assessment and formulation of strategies for developing rapid/ personalized acclimatization schedule and rapid induction of troops.

Gaso-Messengers

Over last two decades at least three gaso-messengers—NO, CO and H_2S—have been identified and qualified as authentic second messengers to regulate vascular homeostasis (vaso-modulation), a phenomenon of central significance in HA adaptation and illnesses. Studies carried out at DIPAS, and elsewhere, have shown that these gaso-messengers are augmented under various pathophysiological conditions at HA and are attractive target for development of diagnostics and therapeutics. DIPAS is working on the development of prospective predictive markers as well as possible therapeutic candidates. The major challenge to test and utilize these molecules for this purpose include limited technical capacity of their accurate on-field detection from minimally invasive biological samples such as blood and non-invasive biological fluids such as breath and saliva samples. Strategies including screen-printed carbon electrodes for sensitive and accurate detection of molecules including nitrate and nitrite have been tested in DIPAS with encouraging results. In this regard, co-immobilized proteins with oxidoreductase activity on the electrode surface appears to be a promising strategy for increasing specificity of such electrodes.

High Altitude induced Thrombo Embolic Disorders

Identification of Biomarkers and Natural Anticoagulant Compounds

The increased incidences of venous thromboembolism (VTE) have been reported from HA regions. Hypobaric hypoxia along with other environmental conditions alter the coagulation cascade to create a prothrombotic milieu at HA. Vascular thrombosis, whose main clinical presentations include deep vein thrombosis and pulmonary embolism, is getting recognized as a major health problem at HA. The global burden of

Hypoxia Exposure with physiological monitoring

VTE shows overall annual incidences of 0.75-2.69 per 1000 population and 2-7 per 1000 in elderly (≥70 years). Various studies show that hypoxia, dehydration, heme concentration, use of constrictive clothing, and enforced stasis because of severe weather, may result in formation of blood clots at HA leading to thromboembolic disorders (HA-TED). High incidence of thromboembolic disorders (TED) has been anecdotally reported in lowlanders posted at HA impacting lives of thousands of soldiers. Further clinical trials have indicated that about a year stay at HA is associated with a 30 times higher risk of thromboembolic events including DVT and PE. Till date the most commonly used clinical marker for VTE diagnosis is the D-dimer test, which detects endogenous fibrinolysis. This test often gives false positive results and has low specificity. Also, early diagnosis of VTE is often difficult, which delays treatment resulting in sudden deaths. The present anticoagulant treatment strategies have risks of haemorrhage and require regular monitoring of patient.

DIPAS has screened natural compound library to identify natural anticoagulants and their synthetic derivatives by blind docking followed by evaluation of lead compounds for their antithrombotic potential against HA-TED.

Analysis of various genetic predisposing factors are being done for classifying individuals susceptible to HA-TED. This involves candidate gene association studies and epigenetic studies such as methylation and identification of suitable MiRNAs. These genetic predisposing factors could either be used as screening tool for VTE susceptibility or can also be used as early diagnostic markers for VTE. Some of the significant findings in this area are:

⌘ Identification of herbal compounds identified with anti-thrombotic potential: Pravastatin, wogonin, hyperoside and diosmetin as promising lead compounds can act as pharmacological agents for thrombosis in future. Validation of these compounds in in-vivo model showed that Pravastatin has maximum anti-thrombotic potential.

⌘ Targeted gene expression analysis revealed unique genes differentially expressed in HA-VTE patients in comparison to SL-VTE patients and resistant controls.

⌘ Differential proteomic analysis revealed five important protein molecules, which showed significant differential expression (DE) between VTE patients at different altitudes. Two of these DE proteins are being used for developing field-based diagnostic test for early VTE detection.

⌘ Candidate gene association studies revealed that single nucleotide polymorphisms in VKORC1, CYP2C9, TAFI, F11, GP6 and COX2A are associated with VTE susceptibility.

⌘ Epigenetic studies showed that in HA conditions, the DNMT molecules methylate the CpG dinucleotides at the promoter site of thrombomodulin (TM) gene thus reducing the transcription. This may contribute to thrombotic complications.

Differential expression levels of hsa-miR-320 are associated with etiopathology of VTE at sea level and at HA and can be used as novel diagnostic biomarker of VTE at HA. Also, two miRNAs, hsa-miR-195 and hsa-miR-103a can be further explored in animal studies and could be evaluated as biomarker for VTE diagnosis in general.

Pharmacological & Nutraceutical Interventions at HA

In case of emergency, when proper acclimatization in actual HA condition is not possible, the use of pharmacological agents such as acetazolamide and glucocorticoids have been found beneficial to prevent AMS. Studies at DIPAS have shown that hypoxia preconditioning with hypoxia mimetics and inhibitors of prolyl hydroxylase like cobalt chloride and EDHB (ethyl-3,4 dihydroxy benzoate, a herbal product) stabilizes hypoxia inducible factor (HIF-1 α) and triggers acclimatization response.

Inhalation of 15 ppm NO along with oxygen has been found beneficial in treatment of HAPE. Increased level of oxidative stress and inflammation are observed behind the pathophysiology of HA maladies. Extensive research using simulated conditions and experimental animals have led to development of several prophylactic and therapeutic agents of herbal origin. A new simulation chamber for human exposure to hypobaric hypoxia and cold has been installed recently at DIPAS.

Promising protective agents have been found to be quercetin, curcumin,

Human Decompression Chamber for Simulation of Cold and Altitude

nano-curcumin formulation, DIP-GFIT and DIP-CFIT as they have shown to possess anti-inflammatory, antioxidant and performance improving activities through different metabolic pathways (Table 1). Supplementation with dietary nitrate through stabilized beet root juice (developed in collaboration with DFRL, Mysuru) has also been found beneficial for improving cardiovascular health at high altitude. It increases NO levels, normalizes pulmonary artery pressure and improves oxygenation during exercise.

Prolonged and severe exposure at HA decreases body weight leading to loss of skeletal muscle mass and decline in physical performance. Recent studies at DIPAS have reported the progression of skeletal muscle atrophy under chronic hypoxia due to proteome imbalance, chronic inflammation, impaired protein synthesis flux, ER stress load, dysregulated Ca2+, and enhanced protein degradation. Supplementation with Carnosine and Ursolic acid ameliorated HA induced skeletal muscle loss by modulating several key signalling pathways and inhibiting excessive protein degradation under hypobaric hypoxia.

These agents have been thoroughly tested for efficacy and safety along with elucidation of mode of action. Technologies have been transferred for Alocal, NO delivery system, Q-DIP, DIP-GFIT to various firms.

Technologies/Products for Improving High Altitude Habitability and Sustenance

Improved Bukhari

Improved version of kerosene-based bukhari (device used to keep living space warm) has been inducted

in the Army. This device is fuel efficient, safe from carbon monoxide emission (levels below detection limits) and fire hazards. The double walled jacket, special wick burner and exhaust system with protection against backflow of air

Table 1. Therapeutics, pharmacological agents and nutraceuticals for high altitude

Therapeutics/Nutraceutical/ performance enhancer	Benefits
Alcoal	An Aloe vera-based non-greasy cream, effective prevention of chilblains and frostbite. Alocal is in regular use by armed forces.
Nitric oxide therapy and NO delivery system	15 ppm NO along with oxygen has been found very effective in treatment of HAPE. Delivery system, which mixes gases on-board, is safe as it prevents formation of nitrous oxide.
Beetroot Juice a source of dietary nitrate	Improves nitric oxide, maintains vascular health, improves work performance, suitable for high altitude.
Q-DIP Quercetin food bar	Antioxidant and anti-inflammatory; can prevent HAPE.
C-DIP Curcumin food bar	Antioxidant and anti-inflammatory; can prevent HAPE.
DIP-GFIT	Derived from medicinal mushroom *Ganoderma lucidum*. Improves performance and maintains cellular integrity.
DIP-CFIT	Derived from *Cordyceps*, mushroom improves performance under stressful conditions.
Nanocurcumin formulation	Contains nanocurcumin and pyrroloquinoline quinone. Anti-inflammatory, antioxidant and has been found very effective in prevention of right ventricular hypertrophy in pre-clinical studies.

are some of its key features. It uses about 60 per cent less kerosene oil in comparison to existing bukharies, thus saving huge quantity of oil. One bukhari on an average saves about 8-10 litre kerosene per day. The burner is easily removable and can be also used for warming of food and water. The design has been patented and technology has been transferred to nine firms.

Oxygen Enrichment and Use of Solar Energy

Keeping the living space warm is an essential requirement at HA and requires electric power or kerosene oil to keep burning warming devices. Both, electric power and kerosene oil, are scarce in remote mountain areas. Generators at HA do not work efficiently due to oxygen deficiency. Lack of power makes the problem of cold even more severe. On the other hand, natural power sources like wind and solar energy are available in plenty.

DIPAS has used solar energy for heating the dwelling shelters using greenhouse effects. Though this technology was in use for greenhouses, but was never tried for a dwelling unit. Roof of dwelling unit was made transparent using polycarbonate sheet to trap the heat. For power generation, sunlight and wind energy were used to make the shelter self-sustaining. As no additional heating device is now required during day, saving of large quantity of kerosene oil used for generation of power has been achieved.

For specialized operations of short duration, when acclimatization is not possible due to want of time or in case of medical emergency like in case of HAPE patients when evacuation is not possible due to logistic reason, oxygen enrichment is the only solution. Oxygen enrichment provides extra oxygen under the hypoxic environment by increasing the amount of oxygen (per cent of oxygen) in a relatively closed enclosure with the help of an oxygen concentrator, which in turn increases the amount of available oxygen molecules in the air and increase in the respiratory oxygen uptake resulting in the improvement in tissue oxygenation and preventing in hypoxia related medical aliments at HA.

It has been reported that increasing oxygen concentration by one per cent decreases the effective altitude by 1000 ft. Experiments carried out by DIPAS confirmed that inhaling 27 to 30 per cent oxygen at 16000 ft is sufficient to maintain a SpO_2 level of more than 90 per cent.

Oxygen enriched shelter meant for 50 persons has been developed by DIPAS and installed at Giagong (North Sikkim) at an altitude of around 16000 ft. For trapping maximum heat, a polycarbonate sheet has been fixed on the south facing side at a steep angle so that snow does not accumulate on this side. The particular angle and design for trapping maximum heat has already been patented.

Salient Features

- Modular structure. PUF panels for insulation under subzero conditions.
- Provision of sitting room, sleeping room, medical room, equipment room, etc.
- Passive solar heating is done with double layered polycarbonate sheet at specific angle.
- PCM for storage of excess heat energy for use during evening hours.
- Provision for oxygenation of sitting and sleeping room depending upon the requirement; Forty LPM oxygen concentrator for oxygen supply and for filling cylinders. Sensors and controllers for oxygen and CO_2.
- Ten Solar panels of 200 watts each for solar power generation.
- Lithium ion batteries for better performance at HA.
- Heat traced plumbing system to avoid freezing of water in pipes.
- Fire alarm system and appropriate fire extinguishing system as per safety norms.
- Eight KVA standby DG set.

Oxygen Enrichment Facility at Chang La with Low Purity High Flow Oxygen Concentrator

In most of the oxygen enrichment facilities, oxygen concentrator with medical grade oxygen have been used. Oxygen with 93 per cent purity is generated and is diluted to make it 27 per cent which is wastage of energy in other words. A new concept of low purity high flow (LPHF) has been used by DIPAS for generation of oxygen with 30-40 per cent purity but with corresponding higher flow rate. Higher flow rate prevents build up of CO_2 level

Solar-heated Oxygenated Shelter for 50 persons

Oxygen Enrichment Facility and LPHF Concentrator (right) at Chang La

inside the enclosure. For this purpose, a special concentrator was designed and developed, which provides oxygen with purity of 40 per cent at 130 litre/min. The facility has been established at DRDO Research Station Chang La, the highest terrestrial lab of the world (17664 ft) recognized by the Guinness World Records. This facility will be quite useful for the forces as well as for the civilian going to/or passing through Chang La.

Solar Snow Melter

At HA there is scarcity of water as it flows down to valleys or remains in the frozen state. Most of the time available snow is melted to meet water requirement. Army posts located in HA areas use Kerosene stoves for melting the snow. Transportation of fuel to the remote areas is another problem. At some places, fuel has to be air lifted, adding to the cost to exchequer.

To overcome these problems, a solar operated snow melter has been designed and developed by DIPAS. The solar snow melter allows the shorter wavelength IR (Infrared) rays inside the melter. The emitted IR radiations from heat exchanger having longer wavelength cannot escape because of insulated double walled polycarbonate sheet raising the temperature inside the cabinet. The copper heat exchanger melts the snow and provides the water, which remains stored inside the seven litre capacity stowage tank. The

Solar Snow Melter

melter consists of an outer box made of GI sheet. The inner container is made of stainless steel to prevent any rusting. Between the two containers there is a layer of PUF to make it insulated from the chilling environment. The system is very easy to operate even by any unskilled person. Snow melter was tested at Khardung La (18380 ft) and showed satisfactory results and provided about 5-7 litre water/hr depending upon the sunshine even under sub-zero conditions.

Heat Stress Physiology & Evaluation of PPE during Exposure

Our international boundary runs through hot dry Thar desert and wet swamp of the Rann of Kutch. Decreased performance due to high ambient temperature, intense solar radiations, hot winds and loose sandy terrain are observed in desert. Similarly, hot humid environment prevalent in coastal regions and jungles causes even more discomfort as cooling effect of sweat evaporation gets compromised. Work or exercise in hot environment causes heat stress and depends on the individual's metabolic rate and capacity for heat exchange with the environment. Physical work increases resting metabolic rate 5 to 15 times. The effectiveness of the thermo-regulatory mechanism of body depends on acclimatization status, aerobic fitness and hydration level of an individual. When core temperature of body rises above 41 °C due to heat exposure there are chances of failure of thermo regulatory mechanism, and physical and mental performance deteriorates rapidly, which may cause a heat stroke. Proper acclimatization reduces physiological strain with respect to heat stress, improves physical work capabilities, thermal comfort, and protects an individual from heat-related disorders.

The main biological response for heat acclimatization is the lowering of sweat threshold. In a survey by DIPAS it was observed that 55 per cent heat illnesses were due to exercise-induced heat exhaustion and 24 per cent cases of heat pyrexia reported on the days when temperature was between 41-43.5 °C. Therefore, it was suggested to avoid outdoor activities between 1100-1700 hr in months of June and July, which has resulted in complete prevention of heat casualties in Armed Forces. The existing acclimatization schedule being followed by Indian

Human Climatic Chamber for Simulation & Heat Acclimation. Below: Inside View

soldiers is 110 min heat exposure with sub-maximal work daily for eight days.

Heat acclimatization is short lived if individual is exposed to cold climate for few days, which requires re-acclimatization of at least 3 days. Decrease in physical work capacity and cognitive functions is observed at 3 per cent hypohydration (measured as per cent weight loss after heat exposure). Significant decrease in plasma volume at 3-4 per cent hypohydration was observed using iodinated serum albumin as tracer. Hypohydration of 3 per cent is easy to recover using water and hydration drinks, but at 4 per cent hypohydration it takes time to restore hydration level and it indicates loss of water from intracellular compartments. Based on these studies use of K+ rich fluid has been suggested.

Adequate fluid replacement overshadows all other considerations of nutrient requirements in a hot environment. Drinking adequate water in hot conditions prevents dehydration, heat illness and helps in maintaining performance. Thirst is a indicator of hydration status. Intense thirst is generally noticed at 5 to 6 per cent body weight loss due to hypohydration. By this time individual's physical performance is already compromised. About 80 per cent of the energy metabolized during exercise in hot environment is liberated as heat and only 20 per cent is utilized as mechanical work. Around 80-90 per cent of heat dissipation during work in a hot-dry environment is accomplished by the evaporation of sweat. Each milliliter of sweat evaporated from the skin leads to heat loss of approximately 0.6 kcal. Sweating rate vary from individual to individual and may reach up to 2 litre per hour. Our studies, under dry desert conditions, have shown that 9-10 litre of water and 16 g of salt intake per day is sufficient to prevent hyponatremia. There is a difference in sweat gland activity of efficiently acclimatized individual's back and forearm the main body parts that provide efficient cooling. To prevent hypohydration, fluid should be taken regularly whether one is feeling thirsty or not. Taking water before prolong work in heat is less beneficial compared to same quantity sipped during short intervals during working.

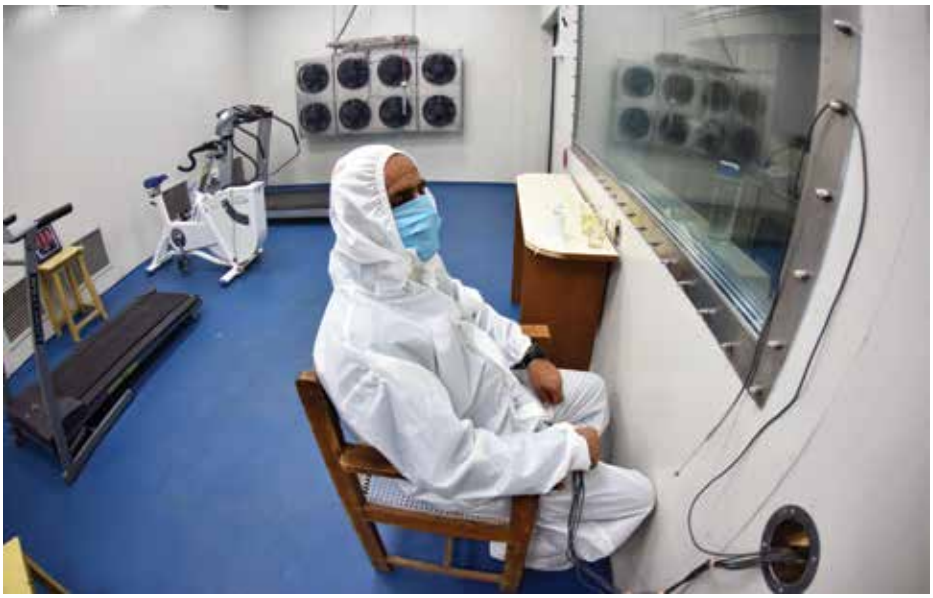
DIP-SIP Replenishment Drink for Heat Stress

Studies in simulated as well as under hot desert environment show that hypohydration results in decreased physical and cognitive performance. Cognitive functions decline at four per cent hypohydration as loss of intracellular water is very difficult to replenish. Sweat loss can be as high as two litre per hour and significantly depletes electrolytes and minerals like magnesium, zinc and selenium. A replenishment mixture DIP-SIP has been developed by DIPAS based on electrolyte loss in sweat during heat exposure. Laboratory and field studies have indicated its suitability in prevention of dehydration and electrolyte imbalance in comparison to other beverages. DIP-SIP has shown to prevent rise in core and skin temperature, maintains cardiac function by maintaining hydration level. It is available in two flavours, i.e., Orange and Litchi.

Replenishment Drink DIP-SIP

Evaluation of PPE for Thermal Strain

Personal protective equipment (PPE) provides protection for defence personnel, health care workers, industrial workers, etc., by preventing human contact with nuclear,



PPE testing in Human Climatic Chamber

biochemical and biological pollutant and potential transmission of communicable diseases. However, PPE can also introduce an additional physiological burden from potentially increased heat stress. Excess heat stress is produced by ensemble due to the textural nature of clothing, multilayer in fabrication, bulkiness of ensemble, breathability nature of clothing and several other structural and functional aspects of ensemble. Metabolic heat production of the user also adds to the heat stress. Protective ensemble hamper heat dissipation, which also adds on the heat stress to the wearer. Therefore, physiological evaluation of protective ensemble is necessary to assess its thermal property especially for the users in the tropical zone; it is very essential to understand the level of toleration or upper limit to which a person can work to avert morbidity and mortality.

DIPAS has established a Human Climatic Chamber Facility for physiological evaluation of PPE. It is a walk-in chamber having air lock chamber (for preparation of experimental subjects) and a main chamber with simulation capability to conduct experiment. The facility has capability to simulate temperature ranging from -5 to 60 °C and RH from10 to 90 per cent.

Stand-work-heat-stress test protocol formulated by DIPAS for performance evaluation of PPE of NBC protective ensemble, impermeable decontamination suits, combat free fall suit is being used for physiological evaluation of PPE Covid-19 ensemble.

Energy and Nutrient Requirements of Soldiers

Adequate nutritional support plays important role in maintaining optimal health of troops. Total energy expenditure (TEE) is the main determinant of energy requirements for adults. The amount of energy requirement is based on basal metabolic rate (BMR) and physical activity (PA), which varies with nature of deployment. Measurement of energy expenditure (EE) is difficult under free living conditions especially during combat missions. However, at units when soldiers have defined work schedule, factorial method for assessing EE using oxygen consumption under simulated conditions and recording time spent in activities can be used to compute TEE.

An important breakthrough in measurement of energy expenditure is the application of doubly labelled water (DLW) technique to human subjects under free-living conditions, which is now accepted as the gold standard. This method involves the ingestion of a dose containing stable isotopic water ($^{2}H_{2}O$ and $H_{2}\ ^{18}O$) and periodic collection of urine sample for estimation of washout kinetics of ^{2}H and ^{18}O. TEE is calculated using estimate of carbon dioxide produced from difference in elimination rates of two isotopic species over a period of 15 to 21 days. Although the method is fairly accurate but high cost of isotopic water and requirement of Isotope Ratio Mass Spectrometer for measurement are limiting factors in its use on large number of participants. DIPAS has established Isotope-Ratio Mass Spectrometer (IRMS) Facility with Gas Bench for using this technique. Accelerometer-based monitoring devices are also being used during different field studies against DLW technique.

DIPAS has developed 17 different ration scales for different climatic conditions and based on the operational needs of the Indian Armed Forces. The ration scales are based on field studies conducted by monitoring food intake of the Indian soldiers over a period of three months. Nutrient balance was taken as basis of recommendations after taking kitchen and plate wastages into account. As a practical approach, the energy balance needs was achieved on weekly basis since it was very difficult to maintain daily intake levels matching with energy expenditure. During military exercise or on the day of intense physical activity, food intake was normal or below normal. Energy balance by troops is generally achieved by increased intake on return to units. The estimated calorie requirement is about 3800 kcal/day at plains. The composition of basic ration scale of Indian soldiers is well balanced as energy contributed from carbohydrate, fat and protein is 61, 27 and 12 per cent, respectively, and comprises items from all five basic food groups. Recommendation of carbohydrate in

Isotope Mass Spectrometer with Gas Bench

ration is 450 g for optimum performance and is a mixture of complex and simple carbohydrates so that food remains palatable. Army rations are able to provide 1.2-1.5 g/kg protein and average intake by Indian soldiers has been found to be about 118 g/day. After meeting protein and carbohydrate requirements emphasis was given to derive 22-27 per cent of total energy from fats. Use of different types of oils was recommended to balance n6 to n3 ratio of fatty acids. Energy and nutrient requirements during trainings and at HA are more in comparison to plains. At extreme altitude loss of appetite due to anorexia is a problem due to changes in certain appetite regulatory peptides and hormones and taste sensitivity. Oxidative stress is also more at HA, therefore, there is extra requirement of antioxidant vitamins and minerals (Vitamin C, Vitamin E, selenium and zinc). DIPAS has suggested special ration above 12000 feet AMSL.

In a comprehensive study data from 53,023 participants from all the three forces (Army: 48,210; Navy: 2,290; Air Force: 2,523) at 267 number different units were collected by DIPAS and analyzed for different aspects and factors governing satisfaction level. This is the largest nutritional study conducted so for in Indian Armed Forces regarding food preferences of troops deployed under different climatic conditions. Study highlighted improved satisfaction level of troops as outcome of different measures taken by Army to provide nutritious and balanced diet based on DIPAS studies.

Nutritional requirements of paramilitary forces (BSF and ITBP) have also been evaluated along with adequacy and satisfaction level of troops about food served to them at different locations. One nutritional software for healthy menu planning in collaboration with INS Hamla has been developed for use onboard ships and establishments of Navy. Sophisticated analytical equipment like Isoperibol Bomb Calorimeter, HPLC, ICPMS, GC-MS and IRMS are available with lab.

Gas chromatograph with Mass Spectrometer. Inset: Inductively Coupled Plasma Mass Spectrometer

Sleep, Cognition & Combat Efficiency

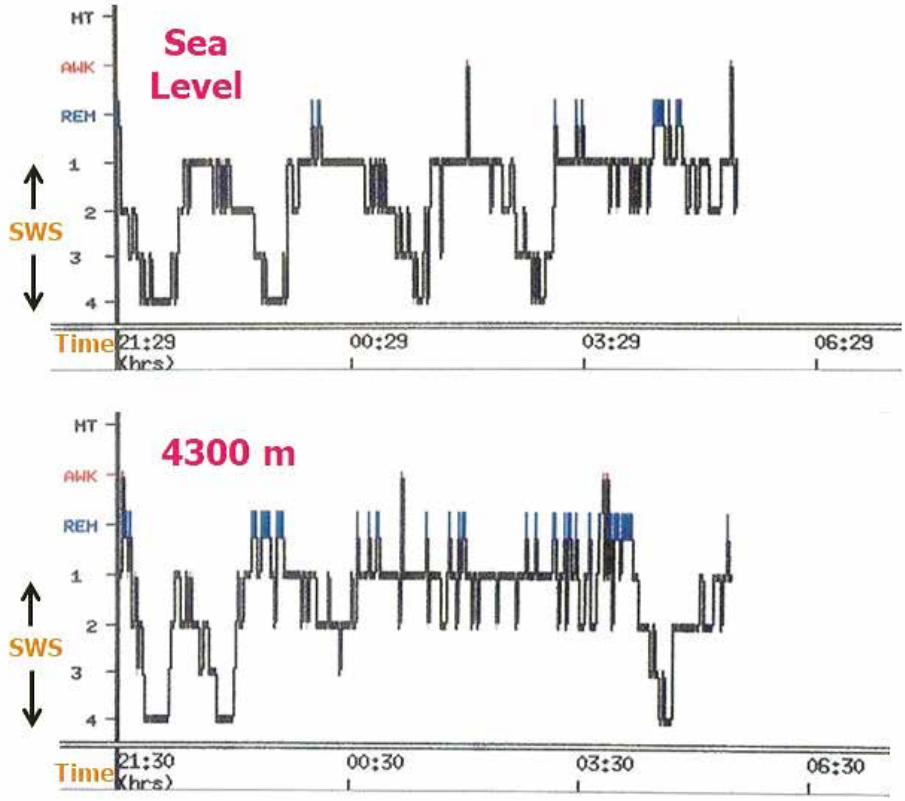
Sleep is a biological need, critical for sustaining the mental abilities and cognitive processes needed for success during combat operations. Soldiers require 7 to 8 hours of good quality sleep every day in order to sustain operational readiness. The most immediate human performance factor in degradation of military effectiveness is poor cognitive performance due to sleep deprivation especially during unpredictable and long-term operations in a combat environment. Sojourns at high altitudes are characterized by sleep disturbances with frequent awakenings, changes in sleep architecture and reports of poor sleep quality.

DIPAS studied sleep architecture of the soldiers posted in Eastern and Western Himalayas in the first week, first month, and six, 12 and 24 months of their residence at high altitude and

after their de-induction to sea-level. An increase in the number of awakenings and sleep latency and a decline in sleep efficiency, a decrease in stages S3 and S4 of NREM sleep, an increase in stage S2, decrease in REM sleep and periodic breathing was recorded at high altitude. Besides, the number of position changes, heart rate and apnoea counts increased while SpO_2 and $EtCO_2$ decreased during sleep at high altitude. Subjective sleepiness score showed a poor sleep quality at high altitude. De-induction to sea-level presented with no significant changes after one month.

DIPAS is working on simple strategies that can attenuate the negative effect of sleep deprivation. The effect of Modafinil and caffeine have been studied on Indian Army soldiers as pharmacological interventions after 24 hours of sleep deprivation. Modafinil is a wake promoting agent and is currently prescribed for narcoleptic-associated somnolence, shift-work sleep disorder, and obstructive sleep apnea syndrome. Modafinil at a dose of 400 mg/day was found to be an effective countermeasure to maintain alertness and reduced lapses in attention and orientation after 24 hours of sleep deprivation. Caffeine (400 mg/day), a non-selective antagonist of adenosine receptors, has been found effective in maintaining the cognitive efficiency despite 24 hours of sleep deprivation.

Scheduled naps and meditation training, non-pharmacological interventions, which have added advantage of being devoid of any side-effects were used to reduce cognitive deficits during sleep deprivation. Napping, a short period of sleep, is one strategy to increase attention and concentration as a possibly useful fatigue countermeasure. A 30-min nap, between 1.00 and 3.00 a.m., during night sleep deprivation improved cognitive function following 24 hours of sleep deprivation.



Hypnogram showing disturbed sleep at high altitude 4300m

Meditation is known to have beneficial effects in psycho-somatic behaviours. It increases brain wave coherence, self-actualization, feeling of vitality and rejuvenation, happiness and emotional stability. It decreases anxiety, depression, irritability and moodiness. DIPAS found two months of meditation practice significantly relevant in ameliorating the detrimental effect of 36 hours of sleep deprivation on higher executive functions in a sample of Indian Army soldiers.

Cognitive retraining is a therapeutic strategy that seeks to improve or restore a person's skills in the areas of paying attention, remembering, organizing, reasoning and understanding, problem-solving, decision-making, and higher-level cognitive abilities. Cognitive retraining for 60 days prior to 36 hours of sleep deprivation improved the cognitive performance of soldiers indicating its effectiveness in improving combat efficiency.

Another strategic approach to improve the cognitive function is sleep banking or sleep extension to counter the cognitive insult arising due to total sleep deprivation and sleep restriction. Sleep banking is defined as storing sleep in advance of a tiring event making a soldier better equipped to deal with challenges due to sleep lost.

Inadequate sleep and subsequent mental fatigue effects combat efficiency, individual safety, mission success, and eventually national security. The aforementioned modalities can ameliorate cognitive derangements due to sleep loss prevailing during combat situations under different terrains.

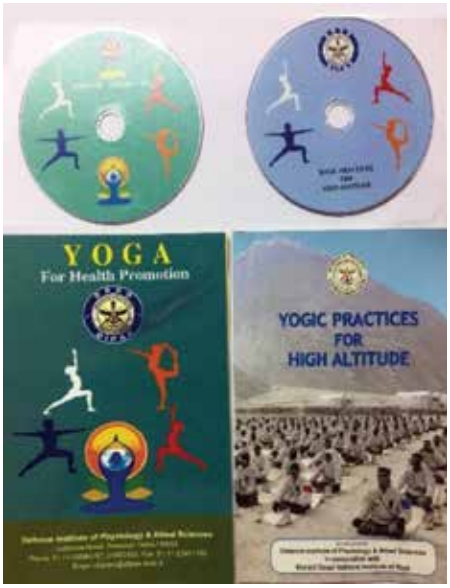
Customized Yoga Packages

There are several situations like extreme altitude, posting at pickets and insurgency area, where it becomes very difficult for soldiers to follow regular physical training due to restriction of outdoor activities. Similarly, in case of Air Force personnel maintaining resilience

is very important because of working with extreme machines, the military aircraft. Also, exhaustive exercises can lead to generation of higher amount of damaging free radicals in conditions like HA hypoxia. Yoga (asanas, pranayama and meditation) can be performed easily under these conditions. Still the common yoga programme cannot be prescribed due to varied effect of postures on physiological variables.

DIPAS has carried out extensive studies on beneficial effects of yoga on body homeostasis and performance, both mental and physical, of soldiers under different climatic extremes and training. The results showed that yoga improves not only pulmonary and cardiac functions but flexibility also. In different studies at sea level as well at HA, it has been observed that a month's yoga practice increases levels of reduced glutathione and decreases oxidative stress markers like malondialdehydes along with stress hormones like cortisol and catecholamines. During 38th Indian Antarctic Expedition it was observed that yoga practice can prevent polar T3 syndrome, a condition observed in expeditioners due to decrease in thyroxine levels during wintering at Antarctica.

Seven different yoga packages (General Health, Extreme Environments, High Altitude, Navy Sailors and Submariners, Air Force, and Desert) have been developed keeping in view specific needs and physiological changes taking place under different environment and occupational needs. Instructors from Army units are being trained by professional yoga trainers to impart training to larger contingents. A yoga package to improve immunity in time of COVID-19 has also been developed and is under evaluation.



Technologies for Prevention of Air Accidents

Fatigue Monitoring System

Operational cognitive readiness and strategic cognitive readiness are the two vital spheres of cognitive preparedness in stressful environment like cockpit of a fighter plane. Mental fatigue is an important issue of concern for Air Force pilots. A high level of fatigue may result in accidents, leading to loss of precious lives and resources. Aircrew fatigue is a significant contributor of air accidents and can arise from a variety of physiological, psychological and environmental factors, making it difficult to develop a system that can warn an aviator of the risk of excessive fatigue. Available method of assessment is subjective. Hence, an objective and reliable method for the detection of fatigue just before the flight was a necessity.

DIPAS has developed an indigenous, cost-effective fatigue monitoring system (FMS) for pre-flight assessment of Indian Air Force pilots. FMS assesses fatigue of an operator in real time by synchronizing the psychomotor test score while measuring the saccadic parameters. This enables fatigue monitoring of the aviator prior to operating the aircraft. The advantages of the system include: accurate estimation of saccadic parameter, i.e., peak saccadic velocity through multistage de-noising using analog and digital filters, tracking saccadic profile in noise using Kalman filtering and removing blinks by independent component analysis (ICA) in real time. The system comprises of an ergonomically designed goggle frame with embedded electrodes. It also has one signal conditioning unit, which amplifies filters and converts the analog signals to digital format. The digital format of the signal is transferred to a data acquisition system for further analysis. The duration of testing is about four minutes.

The FMS has been thoroughly evaluated and validated in laboratory condition (No. 1 Aero Medical Training

Fatigue Monitoring System

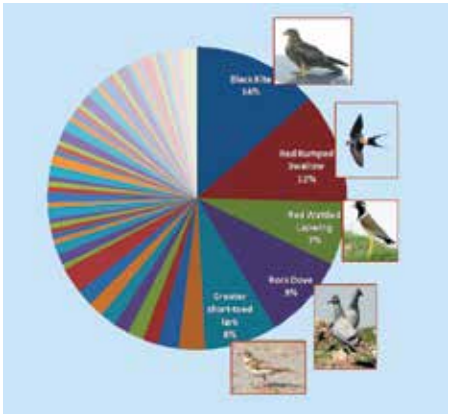
Centre, Hindon and Institute of Aerospace Medicine, Bengaluru) with field trials carried out at various Air Force Stations in fighter, transport and helicopter pilots and found very effective. Patent (201711043780) of FMS has been filed.

DNA Barcoding for Identification of Bird Strike Species

Collisions between birds and aircraft, known as bird strike, have occurred since the earliest days of aviation. Bird strikes are a serious safety hazard and a major expense for the aviation industry. Birds at and near the airport cause majority of bird strikes, which mostly takes place in the landing and departing phase of aircraft. Damage caused by bird strikes is related to impact force, which is proportional to the square of the aircraft's velocity. At normal take off and landing speeds, a two kilogram bird has an impact force of 15,000-40,000 kg.

Directorate of Aerospace Safety (IAF), Indian Naval Aviation HQ and Indian Coast Guard (ICG) Air Station Daman approached DIPAS for identification of bird strike species using DNA barcoding technology to avoid bird collision by identifying the roost/ feeding areas of threat species so that a strategy can be evolved to minimize the problem.

DIPAS analyzed approximately 700 bird strike samples through DNA Barcoding and identified 69 avian species in Indian Air force bird strike incidents and 11 species in Indian Navy bird strike incidents. After analyzing the species identification of bird strike samples, the Ornithology Cell under Directorate of Aerospace Safety formulated certain species specific modules and base specific modules to manage the bird activity around the airfields. This has resulted in approximately 15 per cent reduction in bird strikes incidents and 27 per cent reduction in bird strike damage thus saving significant amount of exchequer. Respective airbases also took control measures specific to their airbases to minimize the occurrence of bird strikes.



Identified Bird Species responsible for Air Crashes

Research on Vaccines, Adjuvant & Complimentary Medicines Therapeutic Modalities

Candidate Vaccine Molecules against Salmonella & Shigella

Salmonella typhi and Shigella are still unsolved problems in the majority of the world. Salmonella infection, ranging from mild, self-limiting diarrhea to serious gastrointestinal and septicemic disease and enteric fever (typhoid), is a global health problem both in humans and animals, with an annual global incidence of 21 million cases and nearly 600,000 deaths. The major causes of prevalence of this disease are related to poor food hygiene and inadequate sanitation. Salmonellosis in poultry is the leading cause of morbidity and mortality in poultry and responsible for significant economic losses in all the phases of poultry industry from production to marketing. Rapid emergence of multi-drug resistance strains has made the control of Salmonellosis a very difficult proposition. The present available vaccines provide only poor to moderate protection, require large doses to be completely efficacious and are expensive.

In recent years, the threat from biological attack has necessitated the development of medical countermeasures to protect against virulent pathogens. As a novel vaccination approach, DIPAS has developed heat shock protein (Hsp)-based candidate vaccine molecules rHsp60 (GroEL) and rHsp70 (DnaK) against Salmonella and found these molecules highly effective in mouse model. Some of the salient features of the vaccine molecules are:

- Stimulates both humoral and cell mediated immune responses unlike Vi vaccine, which stimulates predominantly humoral responses.
- Confer 80-90 per cent protection
- Effective even in the absence of adjuvant, which is an absolute requirement for the traditional vaccines with side effects.
- Elicit cross-protection against other bacterial infections, indicating their immense potential to be developed as single vaccine candidate molecule protective against multiple pathogens.
- Significant (99%) reduction in the fecal bacterial load in poultry, indicating these candidate vaccine molecules as effective molecules against spread of Salmonellosis in poultry.
- Promising carrier molecules for enhancing antigenicity of poor antigens due to their ability to stimulate high antibody titre.

A fusion protein of Salmonella typhi GroEL with protective but weak antigen of Shigella developed by DIPAS elicited significant protection against Shigella infection in mice. Two international patents (US and European) and one Indian patent have been granted.

DIP-HIP

DIPAS has developed a herbal adjuvant, DIP-HIP, which in a comparative study when evaluated with different types of antigens along

with commercially available adjuvants like CFA and Alum, consistently demonstrated immunogenicity with wide margin of safety and long-term antibody sustenance. While maintaining the immunogenicity it does not require the cold chain. This adjuvant can be produced as "point-of-use" by simple physical mixing procedure to generate vaccine formulation that is stable (at 2 to 8 °C for at least three years in the extract form and six months as formulation with antigens) and homogeneous with a reproducible size distribution. Both, humoral and cell mediated immune, responses are generated by DIP-HIP.

Consistent response across different strains and species of animals has been observed in pre-clinical studies. Extensive collaborations with pharmaceutical companies as multi-centric trials have been completed for evaluation of herbal adjuvant with commercial bacterial and viral antigens, for license. The results have confirmed the high potency of adjuvant significantly more efficacious than other widely used adjuvants.

Four Indian patents have been filed. The technology is also compatible with the cause of Green Technologies, and is expected to be contributory to a reduction of the global carbon footprint. Technology has been transferred to an Indian firm ADJUIND Pvt Ltd, Hyderabad.

DIP-HIP Adjuvant

Herbo Healer

Wounds and wound repair abnormalities cause a great deal of physical, psychological discomfort and morbidity among the patients, which imposes a major burden on the healthcare system. DIPAS has developed a potent herbal wound healer 'Herbo Healer' in the form of topical cream using the single herbal component. It promotes rapid and aesthetic healing of normal and chronic non-healing wounds. 'Herbo Healer' is highly effective and has wide applications for skin tears, abrasions, incision, excision injuries, superficial/ deep burns, scalds, bruises and diabetic wounds.

Herbo Healer

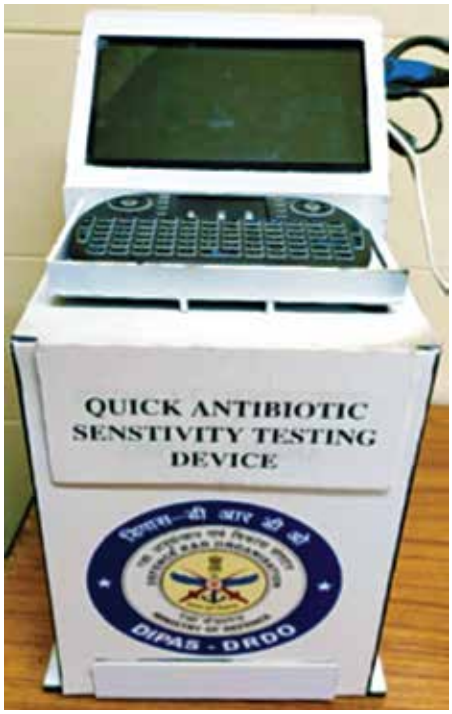
In addition to wound healer, it can be used as personal and preventative skincare. It protects the skin from dryness, heals skin's moisture barrier and provides soothing effects at harsh climatic conditions. Detailed safety and dermal toxicity studies, certified by a NABL accredited lab, exhibited that 'Herbo Healer' is safe for dermal applications.

Quick Antibiotic Sensitivity Testing Device

Pathogenic microorganisms are causative agents of various infectious diseases that are becoming a major concern. Antibiotics or wonder drugs are the antimicrobial agents to treat such deadly infectious diseases. Despite having many side effects, these are the pillars of modern medicine, for curing diseases. But the irregular or continuous use leads to antibiotic resistance (AR) where organisms become resistant to the drug or lose their ability to kill or inhibit the growth of micro-organisms. It is a global healthcare issue. World is losing these miracle cures as resistance against most commonly used antibiotics is increasing. Thus, AR is of particular concern, which may lead to severe consequences and emergence of resistant bacterial strains.

DIPAS has developed a python programming-based device to speed up the process of antibiotic susceptibility testing. The procedure utilized a colorimetric dye, resazurin, a blue coloured fluorescent dye, which gets irreversibly reduced into pink colour within the intracellular reducing environment of live cells. This colour change is monitored using the device.

The Quick Antibiotic Sensitivity Testing Device (QAST) system is composed of a mobile phone that is attached to raspberrry pi (a portable hardware attachment) and a data displaying server, a touchscreen in communication with a Python-based programming application. The application includes a Python Imaging Library (PIL) that adds image processing capabilities to the interpreter. This library supports many file formats and provides powerful image processing



Quick Antibiotic Sensitivity Testing Device

and graphics capabilities. It basically provides rgb value of the captured image. An open CV command accesses the image captured from python code.

The functioning of device commences with insertion of an antimicrobial susceptibility test plate into the attachment proceeded by switching on of the LEDs to illuminate the samples. The phone's camera application is used to capture the image corresponding to each sample in the 96 well plate and then analyzed for change in colour by the program uploaded in the device.

Light-based Wound Healing Therapy

The Phototherapy or photobio-modulation therapy (PBMT) is an emerging and very promising drug-free, painless, non-thermal biophysical healing modality using low-power red or near-infrared (NIR) lights emitted from lasers or hand-held LED devices. This light-based treatment has numerous beneficial photobiostimulatory effects like enhancing wound healing, neuronal repair, mitigation of pain, inflammation, and restores cellular functions.

Cellular mechanism of PBM has been attributed to the absorption of light by components of the cellular respiratory chain. The light absorption at optimum radiant exposure by cellular chromophores elicit photophysical and photochemical events, which induces downstream molecular signaling cascades. The light photons absorbed by endogenous intracellular photoacceptor (principally mitochondrial complex-IV, cytochrome c oxidase; CCO) leads to enhancement of mitochondrial respiration, ATP production, alteration in cellular redox state that elicits photochemical reactions at various biological scales by regulating numerous transcription factors, and intracellular signaling pathways associated with cell proliferation, migration, adhesion, inflammation, pain, apoptosis, tissue repair and regeneration.

LED-based Photobiostimulation Device

Nanotoxicology Research

DIPAS is the nodal lab of DRDO for nanotoxicology evaluation. Nano materials (NMs) being used in military applications require toxicity characterization so that the health of the army personnel as well as civilians can be properly safeguarded. DIPAS is conducting studies to address the nature of NM toxicity based on size, morphology, and surface charge on the circulation half-life and interaction of engineered NMs with biomolecules. Lab is also revealing the cellular toxic mechanisms that impair the normal intracellular processing. To create awareness among DRDO staff on potential toxic effects of intended and unintended exposure to engineered NMs, a monograph entitled "Biological Effects of Nanomaterials and Safety Measures to Mitigate Nanotoxicity" has been brought out and distributed in all DRDO labs as part of 'Safe Use' guidelines. Long-term objective is to evaluate the key biological effects of NMs upon contact with biological system such as bio-distribution, circulatory half life, mechanisms of phenotypic and genotypic toxicity and transmission to generation/s.

DIPAS has established an In vitro and Novel Fly (Drosophila) Experimental Facility to carry out the further research. Laboratory has also successful established a transgenic fly clone (GFP-expressing), to collect in vivo real time physiological, neuronal and molecular data under environmental challenges.

Drosophila melanogaster (fruit fly) is one of the desired model organism for last 100 years in the field of biology, genetics, neurobiology and toxicology. There are many advantages of using Drosophila melanogaster as the experimental model to study nanotoxicity. More than 65-70 per cent of the human disease genes are present in Drosophila. Flies have a short generation time with a large number of progeny. Using Drosophila to study NPs mediated toxicity is cost-effective. With prolonged use of NPs, one of the keen interest is to understand how lethal the toxic effects can be and what is the degree of these effects on subsequent generations. Short life span is advantageous as effect/s of NPs on F0, F1, F2 and so on can be readily studied. Drosophila is one of the remarkable model to look into nano-bio interactions precisely at the molecular level as the whole genome of Drosophila is sequenced and RNAi lines for all the genes are available. Drosophila melanogaster (Oregon R) are cultured on diet containing agar, cornmeal, dextrose anhydrous, sucrose,

Drosophila Melanogaster Culture Facility

yeast extract and nepajin (methyl-p-hydroxybenzoate), an anti-fungal agent. Flies are reared in fly incubator at 25 °C ±1, 60 per cent humidity and 12 h day/night cycle. Toxicity assessment on exposure with zinc oxide nanoparticles (ZnO NPs) has been extensively studied.

Bioinformatics & In Silico Studies

With the advent of -omics technologies (genomics, transcript-omics, proteomics, metabolomics, etc.), the data in biological sciences is increasing exponentially. This valuable data is scattered, unstructured, voluminous and is deposited unregulated in public domain. The challenge that comes with this huge data is that it makes very difficult to analyze, process and derive meaningful interpretation from it. There is a need for systematic attempts to compile, curate, annotate and analyze this data and derive knowledge from it.

Towards this goal, the Bioinformatics Lab of DIPAS has been working towards creating solutions for data compilation, annotation and data-analysis. Several data resources that enable efficient access, management, storage and retrieval of biological data from experimental studies have been developed with analytical tools with user-friendly data-visualization tool kits. The resources include:

HypoxiaDB (http://www.hypoxiadb.com). is a database of hypoxia associated genes and proteins. It is a comprehensive, manually-curated, non-redundant catalog of proteins whose expressions are shown experimentally to be altered at different levels and durations of hypoxia. The database currently contains 72,000 manually curated entries taken on 3500 proteins extracted from peer-reviewed publications selected from PubMed. The database is unique and functional since 2013 and also highly accessed as reflected by the usage statistics.

HAHmirDB (High Altitude Human miRNA database; http://www.hahmirdb.in) is a database of HA human miRNAs and regulatory modules. HAHmirDB is a unique resource that provides a comprehensive and detailed compilation of around 65,000 miRNA-target interactions; 341 miRNA-Transcription factor-gene co-regulatory networks and ~ 10000 tripartite regulons associated with 341 differentially expressed human miRNAs, which have been experimentally validated to be associated with high altitude adaptation. For each miRNA associated with high altitude stress its source, altitude, duration of experiment,

level of expression, Fold Change, Gene Expression Omnibus (GEO) ID, association as biomarker, disease and drug association, tissue-specific expression level, Gene Ontology (GO) and Kyoto Encyclopedia of Gene and Genomes (KEGG) pathway associations are being compiled in the database. HAHmirDB is a unique platform for researchers working in area of high altitude research to explore, compare, analyze and retrieve miRNAs associated with high altitude stress, their coregulatory networks, and FFL regulons.

MyomirDB (http://www.myomirdb.in) is an integrated database and server platform for coregulatory networks of miRNA associated with muscular atrophy. MyomirDB is the first unique resource that provides an exhaustive and elaborate compilation of 247 myomiRs (muscle-associated miRNAs), which have been experimentally validated to be associated with various muscular atrophy conditions; its 56,000 miRNA-target interactions; miRNA-gene coregulatory networks and ~8000 tripartite regulons associated with them. The web resource is a unique server platform which constructs

miRNA-Transcription Factor-target gene coregulatory networks and extracts tri-partite regulons also called Feed Forward Loops (FFLs). This allows mechanistic insights involving the biomolecules of interest and help in generating novel hypothesis for experimental validation.

mirFFLDB (miRNA Feed Forward Loop Database; http://www.mirffldb.in) is a universal repository of Human miRNAs, their targets, co-regulatory networks and Tripartite Regulation. microRNA(miRNA) and Transcription factors (TF) are fundamental transcriptional and post-transcriptional regulators of the gene expression controlling important biological processes. Gene regulation is viewed as a complex process where regulatory elements and their targets form highly complex network interactions. mirFFLDB is a comprehensive

integrated resource for identification and visualization of human miRNA:TF:TG coregulatory directed networks and

their associated FFLs. miRFFLDB also provides an interactive visualization of the coregulatory networks and associated FFLs. miRFFLDB can be used as a comprehensive ready reference resource of miRNA:TF: TG coregulatory and associated FFLs for decrypting complex cellular interactions of these regulatory biomolecules at the molecular level.

These resources enable researchers to explore, compare, analyze and retrieve relevant information, their coregulatory networks and regulatory modules. The web server also allows the users to submit their own data which is compared, analyzed and then provided in interactive visualization tool kits.

Human Factors & Anthropology

This is one of the core areas of DIPAS research that uses measurement of human body dimensions as an art to bring life into designs and innovations by making them population friendly, saving both resources and energy that goes into the whole R&D process. The most recent product being new Personal Protective Equipment integrated with a novel face shield to safeguard the medical personnel, health workers and other users from infectious bio-agents.

The devices that come in handy, during the data survey exercises range from traditional anthropometric instruments like anthropometric rods, calipers and dynamometers to digital anthropometric equipment like 3D Whole Body Scanner. After the extensive data collection, statistical tools are applied to the whole database to deduce useful results, which in turn cater to designing needs of the product. Some notable products and inventions by DIPAS based on anthropology are:

Army Combat Uniform Set Size Rolls

The Combat Uniform Set Size has been developed based on the anthropometric data of the Indian soldiers collected by 3D Whole Body Scanner. This is first of its kind novel Set Size system for the soldiers as they were earlier provided with shirts and trousers from two different sources leading to fitments issues and indirectly hampering their performance. Initially 11 parameters (five for shirt and six for trouser) were considered and after rigorous evaluation the final size were based on Chest Girth for shirt and Navel Waist Girth for trouser. Twelve sizes in sets for the Army uniform have been recommended to cover entire Army population. Same have been accepted and implemented by MGO in 2019.

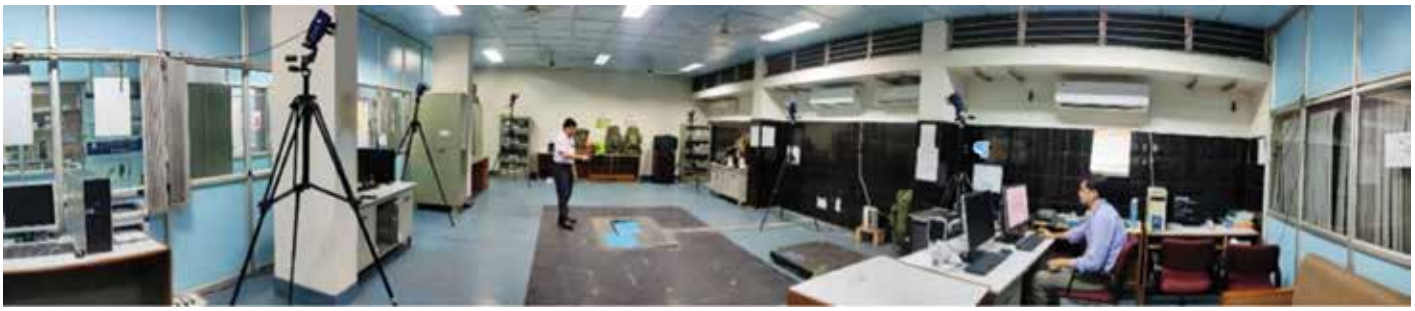
Riot Protection Gear for Female Troops in Action Roles

Female Full Body Protector (FFBP) called Prabla, based on Indian female anthropometry, has been developed by DIPAS with a user-friendly novel design, with ample degree of motion aiding the action role of the female troops while combating. Its lightweight ensemble ensures close combat protection to most vulnerable parts of the body in riot situations, against projectiles and possible threats. Unique features of Prabla are its anti-stab, anti-impact, fire and acid resistant material. CRPF has inducted the gear for her female soldiers. Requests for FFBP have been received from various state police forces from Kerala to Gujarat Police, Assam Rifles and even Anti-Terrorist Squad.

Ergonomic Assessment of Military Workstations, Systems, Arms and Development of Load Carriage Ensembles

Ergonomics is evaluation of the interaction between human and other elements of the working environment or the 'system' to maximize efficiency of target user. Over the last many decades, DIPAS has emerged as a premier institute with facilities for undertaking research in different areas of ergonomics like physical ergonomics, design ergonomics, neuro-ergonomics.

Various studies involve use of Integrated 3D Motion Analysis System for simultaneous measurement of kinematic, kinetic and EMG parameters during human motion like gait while walking, running, using prosthetics and orthotics, load carriage in level



Integrated 3D Motion Analysis Lab

ground and on treadmill, normal and pathological gait, rehabilitation, etc.

Portable breath by breath metabolic measurement is undertaken for measuring physical work load during different activities like walking, running, load carriage on level ground, altitudes, treadmill and different terrains like snow, jungle, sand, etc. Breath metabolic is measured by analyzing heart rate, Oxygen uptake, Carbon Dioxide, Metabolic Equivalent (METS), energy expenditure, etc.

Portable Eye Tracking Glasses, with data acquisition and analysis software, are used to assess mental or cognitive work load in terms of measuring eye tracking parameters like fixation parameters, saccade parameters, blink parameters, pupil diameter and scan path length, etc.

Simulation of human modelling technique for proactive ergonomics assessment of Human-Machine interfacing issues and designing of military workstations, vehicles, equipment and weapon systems in virtual reality platform is carried out by interfacing digital prototype of the military workstation with realistically constrained digital human models (DHM) of target users. During visualization of different activities, ergonomics assessments are carried for parameters like reach envelop, view cone and obscuration, comfort assessment, posture prediction, force generation, torque generation, analysis of low back loading, fatigue, collision detection, etc., and for visualization of work environment and carrying out several iterations of manoeuvres realistically constrained with anthropometric properties of user population. This results in a nearly optimized prototype ensuring increased performance, occupational health and safety with indigenous military product with adequate incorporation of ergonomics considerations, preferably at the conceptual stage of product development.

Neuro-ergonomics Workload Assessment using Eye Tracking Glasses (inset)

Different military products designed and developed by Systems Laboratories of DRDO have been ergonomically assessed by DIPAS for optimization of human performance with enhanced occupational health and safety. Recommendations given by DIPAS have been incorporated by most of the System Laboratories and after requisite iterations, optimized products have been delivered to the users.

At present DIPAS is involved with following System Labs and Ordinance Factory Boards (OFB) for optimizing Human-Machine Interfacing issues:

- Multi lab project on “Exoskeleton for Load Carriage Augmentation” (Nodal Agency: DEBEL)
- Multi lab project on “Next Generation Main Battle Tank (Nodal: CVRDE)
- Advance Medium Range Combat Aircraft (Nodal Agency: ADA)
- Joint Venture Protective Carbine (Nodal Agency: ARDE)
- Ergonomics issues of vehicle design and development (Nodal: VRDE)
- Ergonomics issues of Small Arms (Nodal Agency: OFB)
- Ergonomics for seating console for helicopter (Nodal Agency: NPOL)

Military Load Carriage and Ergonomics

Military personnel are required to carry external load, typically comprising of clothing, protective ensemble (i.e. body armour, helmet), combat

equipment (webbing, weapon systems, ammunition, power sources, radio) and sustainment stores (food and water). In addition, military operations may require dismounted personnel to move on foot through various climates and terrains for long and continuous periods. Load magnitude varies according to mission requirements and threat profile. Recent evidences indicate that with advanced warfare technologies and personal protective equipment load on a soldier has increased manifolds.

Excessive external load may adversely impact upon soldier's physical capability (mobility, lethality) and health (survivability, thermal burden). An individual's load carriage capacity is influenced by a multitude of factors categorized as: (i) personnel characteristics, e.g. fitness, body mass, gender, age, injury profile, load carriage exposure and training, (ii) task characteristics, e.g. total external load, distribution of load, movement speed, march duration, load carriage equipment design, work to rest ratio and (iii) environment conditions, e.g. terrain, heat, humidity, altitude in which the task is performed.

Ergonomics assessment of backpacks (BP) currently used by Indian soldiers indicated design limitations in terms of incompatibility with users' body dimensions and short sized scaffolding external frame causing discomfort and pain. DIPAS has designed new models of backpack by applying ergonomics principles. Laboratory and field studies carried out by DIPAS show that load carriage with new models of backpack reduced energy expenditure, delayed onset of fatigue, enhanced load carrying capacity and mobility during walking on steeper gradient as compared to similar backpacks available in the market. Some of the product developed for military load carriage for Indian soldiers are:

Ergonomically Designed Backpack (90L)

Salient features of this load carriage ensemble made of nylon 6,6 are:

- Ergonomically designed using indigenous anthropometric data.
- Better fit, comfort, safety and usability
- Durable in strength and water resistance
- Supports higher magnitude of load for carriage (30-40kg)
- Placement of load as per requirement
- Allows normal swing of the arms, ensures better balance and stability during load carriage
- Permits rehydration of individual while carrying load
- Properly fits with back of different size population
- Relaxes the pressure points and better comfort
- Provision for attachment of extra articles
- Proper positioning of load to maintain balance
- Protection against rain, snow, sand storm etc.

90 Litre Ergonomically Designed Backpack with Rifle Carrying Facility and Hydration Pack while soldier carries the BP

Product has been uploaded on Government e-Marketplace (GeM) portal with six ToT holders.

Ergonomically Designed Backpack (70 L)

Salient features of the backpack 70 L are:

- Ergonomically design using indigenous anthropometric data.
- Made of nylon-6,6 durable in strength and water resistance.
- Outer surface is provided with the facility of pouch attachment ladder (PAL) system to attach hydration pack, radio pouch, magazine pouch etc.
- Separate hook-on haversack which can be removed as per need.
- Entire backpack can be protected completely by a nylon cover (housed at bottom most compartment) during bad weather conditions like, rain, snow, sandstorm etc.
- Option of carabiner for carrying/ holding climbing equipment.
- Facility to hold skies and carrying climbing shoes on both side.
- Integrated rifle carrying facility allows normal swing of the arms, results in enhanced balance and stability during load carriage.
- Provision of adequate cushioning at the neck region to relax the neck during patrolling.
- Hydration pack attached with backpack helps in rehydrating the individuals during load carriage.

Backpack: Front view with hydration pack and haversack (left) and back view with spinal support, shoulder and waist cushioning

- The unique design allows the adjustability of the back support for different size populations.
- The new backpack has adequate cushioning on pressure points at shoulders, back and waist regions.

ToT has been made with 5 firms.

Multipurpose Load Carriage Ensemble

This double pack load carriage ensemble is a spin-off benefit and considered as a potential solution to the current load carriage issues faced by school children. Postural deviations caused by load magnitude (20-30 per cent of body weight) and poorly designed school bags adversely affect children health. Some important features of Multipurpose load carriage ensemble are:

- Made of waterproof 900 D Cherry Cord fabric
- Lightweight (700 g)
- Volumes of front pack and back pack is 7 litre and 19 litre respectively.
- The front pack is attached with backpack unit using adjustable straps.
- A total of six pouches/pockets are provided for carrying accessories.
- Bag has adjustable shoulder strap with cushion and detachable for strap with horizontal and vertical adjustability.
- Back and front pack can also be used separately as per requirement/ choice of the students.

Laboratory studies have shown that the combination of front and backpack mode of load carriage (65 per cent load in back and 35 per cent load in front) is safe from biomechanical point of view as it offers (a) better postural balance and stability (b) reduced craniovertebral angle, forward trunk lean, and pelvic tilt in comparison to backpack mode of load carriage.

Combination of back and front pack helps to maintain normal spinal lordosis and kyphosis, minimizes risks of spinal deformities, back pain, musculoskeletal disorders and offers better postural stability during standing and walking. Design Patent granted and Product patent is awaited.

Lightweight Combat Boots

Military recruits walk about 11 km per day absorbing approximately 3.50 lakh Newton impact force while carrying 4.2 kg rifle in hand. The absorbed impact force is transmitted to the joints of lower extremities leading to increased risk of foot injuries. The existing combat shoes are not ergonomically designed, these are without impact force (ground reaction force) absorbing in socks, which contributes not only to injuries during military activities over a long duration but also increases the energy expenditure.

Keeping in view, DIPAS has ergonomically designed lightweight combat boot (< 1.5 kg; size 8) while considering user requirements, viz., flexibility, durability, performance, proper fit, comfort, breathability, water repellent for improved performance, health and safety.

Having core competence in Military Ergonomics, DIPAS conducted series of physiological and biomechanical studies to evaluate the efficacy of the DIPAS developed boot over the existing boots (Directly Molded Shoes-DMS) under various operational conditions.

Salient Features

- Better fit, comfort, safety and usability; Decreases energy expenditure, improved mobility and low fatigue
- Advanced sole system with anti-static outsole, midsole, anti-perforation insole and, visco-elastic insock
- Anti-penetration insole textile in place of traditional steel plate
- Inner lining of breathable fabric
- Outsole impregnated with five different varieties of cleats
- Oil/ acid resistant
- Chrome tanned leather and nylon textile
- Zip at medial aspect of boot

Ergonomically Designed Combat Boot

Lightweight Ergonomic Snow Boot

Developed for operations in severe cold and windy conditions at high altitude and snow-clad regions. Existing indigenous snow boot (RI Boot) is heavy (3.5 kg, size 8), lacks adequate thermal insulation in the foot bed, vamp and ankle areas; lacks a breathable inner lining, and demonstrates poor grip on the snow-covered terrains due to a soft outer sole. Imported boot like SCARPA, LOWA and other brands address many of these problem, however, these are very heavy (> 3 kg, size 8) and costly (> Rs 50,000). DIPAS developed snow boot is based on ergonomic principles and would facilitate/enhance soldiers' performance, comfort and combat capabilities.

Salient Features

- Lightweight
- Ankle support Cuff quarter is attached to the shell with a flexible hinge
- Foot bed with midsole PU/ EVA/ PP

Lightweight Ergonomic Snow Boot

sheet, strobel cloth, PE insole and PU insock

- Grooving at outsole
- Inner lining of breathable fabric
- Outsole with Zic pattern and sand texture high cleats
- Zip at the medial aspect of boot

Prevention of Noise Induced Hearing Loss

Noise induced hearing loss in military and industrial environment is considered one of the most common occupational health hazards. Incidences of noise induced hearing loss are very high in different military and industrial establishments. Mapping of noise level at different places and during operations like firing of artillery guns with effect on hearing and stress level has been thoroughly studied. Two type of ear defenders using passive as well active noise cancellation have been developed.

Active Ear Defender

Besides war, our defence personnel are regularly exposed to high level of noise in their work environment. The ground running of aircraft for routine maintenance and preparation for flights exposes the service crew to noise levels in the range of 120 to 135 dBA. During driving of T-72 tank in limited available area, the sound pressure level ranges from 99 to 105 dBA. Also, there is prevalence of high level of engine room noise inside naval ships ranging from 95 to 113 dBA.

Low frequency noise causes fatigue and annoyance in armed forces personnel working in the high-level low frequency noisy environments. Low speech intelligibility caused by the background noise is also a safety issue since it is the most important that all commands can be understood correctly. Although passive noise control gives high attenuation over large frequency ranges but it is inefficient in providing attenuation of low frequency noise.

Based on destructive interference

Active Ear Defender

Active Ear Defender provides low frequency attenuation in conjunction with high frequency noise attenuation (passive noise control), thus provide noise attenuation over complete audible spectrum. Low frequency attenuation will provide extra noise attenuation inside the ear-defender without attenuating the speech frequencies.

Specifications

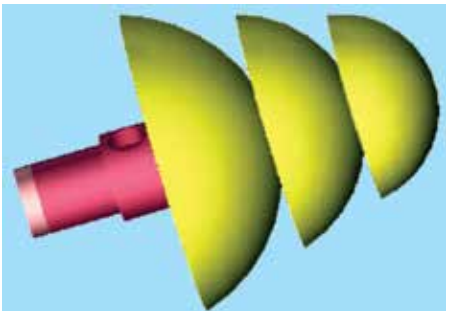
- Noise Reduction Rating: 29 dB
- Real time Passive Noise Reduction: up to 20 dB
- Real Active Noise Reduction: up to 17dB
- Active Noise Cancellation range: 50 - 630 Hz
- Total Noise attenuation range: 50 – 20,000 Hz
- Weight: 375 g
- No dangling wires

Technology transferred to four industries.

Stellar Earplug

Artillery and Armoured Corps personnel are exposed to high intensity impulse noise of 163dBpeak or more during firing. Traditional earplugs attenuate the noise but drastically reduce intelligibility of oral communication (commands and instructions). Stellar ear plug is a level dependent/amplitude sensitive earplug designed to provide protection against the high impulse noise levels encountered during firing of weapons/weapon system. It provides minimal attenuation against background noise which enable discernible communication whereas attenuation increases non-linearly with increasing peak noise level, provides enhanced protection during firing of weapons.

Technology transferred to four industries.



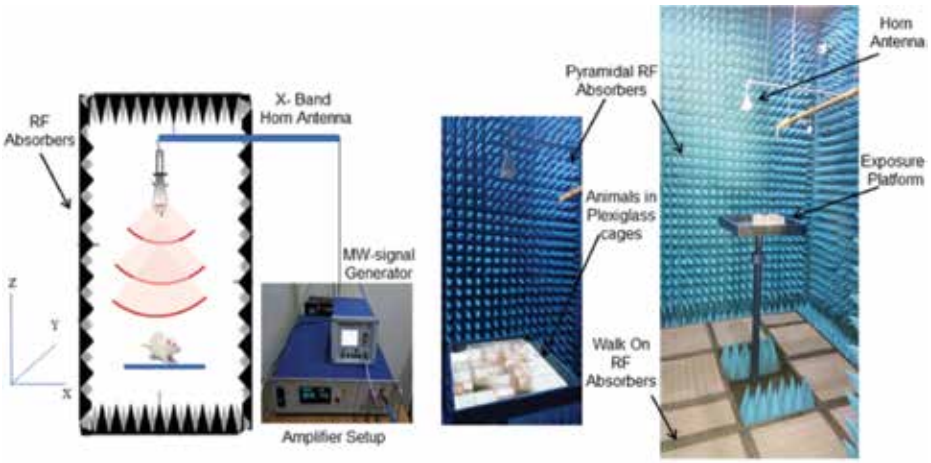
Stellar Earplug

Bio Facilities

Biological Effects of Non-Ionizing Radiations & Anechoic Chamber Facility

Microwaves (MW) are non-ionizing radiation used across different fields of military and commercial applications for wireless telecommunication, long-range signal transmittance for radar surveillance, satellite telecommunication, surface topographical scanning and wireless networking, etc. The increased uses of MW-assisted technologies are raising the concern of its associated biological effects and potential risks on human health.

MW radiation interacts considerably well with biological entities in different ways depending on different physical parameters like frequencies, power-densities, wave-forms, modulation, exposure duration and dielectric properties of biological tissues such as conductivity, permittivity, along with shape and orientation of the object. The biological effects exerted by the different kinds of MW frequencies might be different owing to variation in the properties like penetration, carrier-



Anechoic Chamber Facility

ability, reflection and absorption into the tissue. Interactions of MW energy with biological entities eventually culminate into thermal as well as non-thermal effects that could lead to perturbations at molecular and cellular levels, which can eventually lead to different types of disorders. The increased public exposure to MW-induced radiation heightened the need to evaluate human health effects. The evidence agglomerated the scientific community to actuate and design comprehensive scientific studies of MW dosimetry to better understand the molecular basis and interaction mechanisms of these radiations and their impact on biological systems.

A highly sophisticated infra-structure of 'Fully-Shielded Microwave Anechoic Chamber' has been established at DIPAS. The facility aids to evaluate the thermal and non-thermal implications of broad-range of radio frequency (RF) radiation exposure (900 MHz-100 GHz) on experimental animal models by monitoring physiological responses, alterations at biochemical, cellular and molecular levels. This facility can be used for dose-response studies by using varied RF physical parameters, real-time behavioral monitoring of exposed animals for risk assessment, health hazards and to generate safe exposure limits.

Experimental Animal Resource Centre

Experimental animals are used to understand the intricacies of acclimatization, disease processes and to find out solution to the health problems of the persons employed in harsh climatic conditions. To cater to the demand of the experimental animals, DIPAS is having a moderate size centralized Experimental Animal Facility with state-of-the-art infrastructure.

The animal facility is an exclusive area distributed over two floors with 'One-way Corridor System' to minimize the cross contamination and for the efficient animal facility operations. The ground floor is dedicated to the breeding and maintenance of different laboratory animals. Each animal species is housed separately in individual room to prevent inter-species disease transmission and anxiety due to interspecies conflict. In addition to the breeding unit, there is a separate experimental floor available for holding and conducting the experiments on animals. At present rat (Sprague Dawley strain) and mice (Balb/C and Swiss albino strains) are bred and maintained in the facility.

The facility is registered with the CPCSEA (Committee for the Purpose of Control and Supervision of Experiments on Animals), a statutory committee under Ministry of Environment, Forests and Climate Change, Govt. of India (Registration number: 27/GO/RBi/S/99/CPCSEA) for use of small laboratory animals for research and development purposes. It meets the requirements of the CPCSEA guidelines as well as international norms. An Institutional Animal Ethics Committee (IAEC) is in place as per CPCSEA guidelines to

Colony of Sprague Dawley Rats

maintain and follow the ethics during animal experimentation.

The animals are maintained under controlled environmental conditions (temperature (23±1°C), relative humidity (30-70 %), 12:12 h light-dark cycle with 100 per cent of fresh air exchange in animal rooms through centralized air handling unit. It is supported with qualified veterinarians and skilled animal care staff. Animals are maintained on pelleted diet. The feed provided to the animals is balanced, sterilized and conforms to the laid down standards. Potable filtered water is provided to the animals ad lib. A high degree of personal hygiene and sanitation is being practiced. Sterilization of bedding material, water bottles and cages are carried out using horizontal heavy-duty autoclave and animals are maintained on sterilized material. Feed and water analysis are carried out for ensuring its quality and microbiological contamination. Waste disposal is carried out as per the CPCB guidelines. Furthermore, general health of all laboratory animals is monitored routinely and any deviation from the normalcy is taken care of, following appropriate veterinary medical aid. Specific health monitoring with respect to microbiological health is done quarterly.

Combat against COVID-19

DRDO has emerged as a critical force multiplier in fight against COVID-19 pandemic. Many DRDO labs are engaged in developing medical equipment from available technologies to develop essential items for mitigation of the deadly pandemic. Some of the mitigation technologies developed by DIPAS are:

Molecular Investigation Facility for Detection of COVID-19

A new facility for detection of severe acute respiratory syndrome Corona virus 2 (SARS-CoV-2), commonly known as COVID-19 has been established at DIPAS. This is an enhanced BSL-2 containment (Biosafety Level 2 Plus; BSL-2+) facility for detection and undertaking the research with viral vectors, arboviruses, and other emerging infectious diseases. The facility contains separate sample collection area, personal protective equipment donning room, virus inactivation room maintained at negative pressure containing biosafety cabinet (Type B-2) and virus burnout unit, RNA isolation room, Pre-PCR room, PCR and reporting room, doffing area and bio-waste management area as per ICMR guidelines. The facility is equipped with QuantStudio 5 Real-Time PCR System (ThermoFisher, USA) and CFX96 real-time PCR detection system (Bio-Rad Laboratories) and compatible with all the available approved COVID-19 RT-PCR detection kits.

Customized UV-C Sanitization Box & Hand-Held Device

As a part of preventive measures against transmission of Corona virus, DIPAS has configured and developed an UV Sanitization Box and a Hand-held Device based on ultraviolet-C (UV-C) light, a shorter wavelength (λ ~ 254 nm) light particularly good at destroying the genetic material of SARS-COV-2. The UV-C radiation wraps the structure of RNA by photo-dimerization of pyrimidine, preventing the Corona virus from multiplying in the host cell.

The portable UVC Box is made up of powdered coated MS box consisting of two 8 W UV lamps fitted in top and bottom with SS mirror reflector and steel mesh placed at equidistance from UV lamp. The system weighs around 5 kg and has programmable PCB timer integrated in the device to fix the duration of UV-C dose in the enclosed space in the box. The box can be used for disinfecting surfaces of personal belongings like mobile phones, keys, purse, currency, etc., in 1 minute.

The portable 16″ Hand-Held UV-C Device is made of mild steel. The width of the sanitizer is 4″ and it weighs around 1.25 kg. The outer case of apparatus houses one 8 W UV-C lamps, SS mirror reflector, micro-switch

UV-C Sanitization Box

Hand-held UV-C Sanitization Device

and power supply connection unit. The hand-held device can disinfect office and house-hold objects like chairs, files, postal delivered items and food packets and bigger items like Chair, Sofa, Table, Cupboard, Car, etc., within 45 seconds at dose of 100 mJ/cm^2.

Two-Piece Breathable Coverall

Breathability, ease of donning and doffing without compromising functionality and protection, are certain issues concerning PPE used by front warriors engaged in fighting COVID-19.

DIPAS has developed two-piece Breathable Coverall designed in such a way that its two pieces acts as one-piece functionality. The coverall is double layered in the areas where exposure chances are high, and can be easily donned and doffed in an emergency. It is made up of non-woven, non laminated and breathable fabric and qualifies Synthetic Blood Penetration Resistance Test. The PPE consists of following components to work as a whole unit:

- Head cover to be worn with 3-ply mask & polycarbonate face shield
- Upper jacket to be worn with Nitrile gloves
- Trouser comprise good adjustable waist elastic
- Shoe cover with fastening strips for good coverage

Two-piece Breathable Coverall

Hydrogen Peroxide PPE Disinfectant

Disinfection with Hydrogen peroxide (H2O2) is a low-pressure, low-temperature, nontoxic process that uses vaporized H2O2 to reduce the level of infectious agents. Human health depends on the quality and thoroughness of a surface disinfection. H2O2 is a strong oxidant and can be used as potent broad-spectrum germicide. It belongs to the category of High Level Disinfectant (HLD) and is safer than chlorine to humans and the environment. Disinfectants of this level kill all vegetative microorganisms, mycobacteria, lipid and non-lipid viruses, fungal spores, and some bacterial spores. H2O2 solutions are inherently unstable and decompose over time to oxygen and water. These solutions are packaged in opaque containers to prevent decomposition from external light.

DIPAS has standardized a Fogging Disinfection System for disinfection of PPE and masks.

Specifications

Volume of the chamber: 1296 ft^3
Concentration of H2O2: 5.5 %
Time of fogging: 10 min
Time of dwell: 150 min
Temperature: 30 °C

Fogging Disinfection System

On testing of PPE and mask there was log 4 reduction in microbial growth after fogging. Protocol for disinfection of a 1500 ft^3 chamber/room is:

Concentration of H_2O_2: 5.5 % with 0.01 per cent Silver nitrate
Volume: 600 ml
Fogging time: 10-12 min
Dwelling time: 60-70 min
Temperature: 30±3 °C

Herbal Sanitizer

Washing hands with soap and water or alcohol-based hand sanitizers helps in prevention of COVID-19. WHO recommends hand sanitizer formulation that contains at least 60 per cent alcohol, 1.45 per cent glycerin and 0.125 per cent H_2O_2. However, the main ingredient alcohol has harsh drying effects on skin. Further, prolonged use of H_2O_2 causes peeling and loosening of the skin. DIPAS has developed a herbal sanitizer, called Herbo-Safe, containing 70 per cent Isopropyl alcohol that helps in killing 99.9 per cent microbes and neutralizes the harsh drying effects of alcohol on skin. H_2O_2 has been replaced with natural bio-active extracts exhibiting anti-microbial and anti-viral effects. Both gel as well as liquid forms have been made.

DIPAS has also developed herbal disinfecting towels, Herbo Swachh, for manifold disinfection applications, including multi-tasking cleaning to remove germs, bacteria and viruses from computers, laptops, mobiles, working desks and daily use items. The non-toxic Herbo Swachh can be used by medical and nursing professionals for disinfection and as an alternative to bathing.

Long-term use of protective face/mouth covering devices and appliances, especially during the pandemic, pose problems amongst doctors and nurses due to difficulties in breathing, fatigue and sometimes due to mask phobia. DIPAS has developed a herbal spray, Herbo Shwaas, by using organic components like antimicrobial, antiviral, anti-inflammatory, antiseptic, bronchodilatory, decongestant with soothing properties for the respiratory system and for effective prevention and

Herbal Sanitizers

management of respiratory problems, including viral diseases like respiratory syncytial virus, SARS, MERS, H1N1, influenza A, herpes simplex virus, vaccinia virus, etc. The product being totally natural is non-toxic, soothes and relaxes breathing, eases long-term usage fatigue, disinfects and deodorizes and reduces maskaphobia. It can be effectively applied on various kinds of masks, including cotton home-made masks, gamchhas, handkerchiefs, etc., used by the common man. The formulation is safe, easy to use and useful for Corona warriors, patients with co-morbidities, the general population at large, including children and geriatrics who are at higher risk of developing respiratory diseases and ailments.

Shoe Sanitizer

DIPAS has designed shoe sanitizer mat to disinfect the bottom of the shoes. The mat is scientifically proven for reducing the spread of the germs from outdoors to indoors and is recommended at the entry points of premises visited by a large number of visitors like hospitals, offices, educational institutes, etc. The mat comprises a trough made of stainless steel and a mat. The chemical used for disinfection is Benzalkonium chloride which has been recommended for disinfection against SARS-COV-2. An appropriate concentration, 2-3 litre of solution is sufficient for 4 x 4 feet trough, of this compound needs to be replenished on daily basis. The mat should be washed thoroughly fortnightly or depending upon the usage.

Specifications

Dimensions of the trough: 4 ft x 4 ft x 1 inch

Material of the trough: SS (Grade 304)

Dimensions of Mat: 4 ft x 4 ft

Area to be covered with mat after shoe sanitization tray: 6 x 4 ft

Material of the Mat: PVC

Thickness of the Mat: 16 mm

Sanitizer absorbing foot mat: Cotton mat (30 inches x 20 inches). To be placed just after the long mat (6 ft x 4 ft).

Chemical: 2 per cent Benzalkonium chloride

Volume: 2.5 litre

Standard Operating Procedure: Dilute 50 ml of Benzalkonium chloride to make total volume of 2500 ml. Pour this mixture over the mat in the tray so that it spreads properly.

Car Wheel Sanitizer

This is a mat, which is designed to disinfect the wheels of vehicles (four wheeler and two wheeler). The mat is scientifically proven for reducing the spread of the germs from outdoors to indoors. Especially in the present situation of COVID-19, this is recommended at the entry points of premises visited by a large number of visitors like offices. The mat comprises a trough made of stainless steel and a mat. The chemical used for disinfection is Benzalkonium chloride which has been recommended for disinfection against SARS-COV-2.

An appropriate concentration of this compound needs to be replenished on daily basis. The mat should be washed thoroughly fortnightly or depending upon the usage. 6 litres of solution is sufficient for a 20 ft long trough.

Shoe Sanitizer

Specifications

Dimensions of the trough: 20 ft (L) x 21 inch (W) x 36 mm (depth)

Material of Trough: SS (304), 1.5 mm thick

L Angle : 40 mm x 40 mm x 4 mm

Dimensions of Mat: 20 ft x 21 inches

Thickness of Mat: 16 mm

Material of Mat: PVC

Chemical: 2 per cent Benzalkonium chloride

Volume: 6 litre for each trough

Standard Operating Procedure: Trays should be leveled properly before fixing on the surface so that the liquid spreads equally in the whole tray. Dilute 120 ml of Benzalkonium chloride to make total volume of 6000 ml (6 l). Pour this mixture over the mat in the tray so that it spreads properly a total amount of 12 litre solution is required for both the trays.

Car Wheel Sanitizer

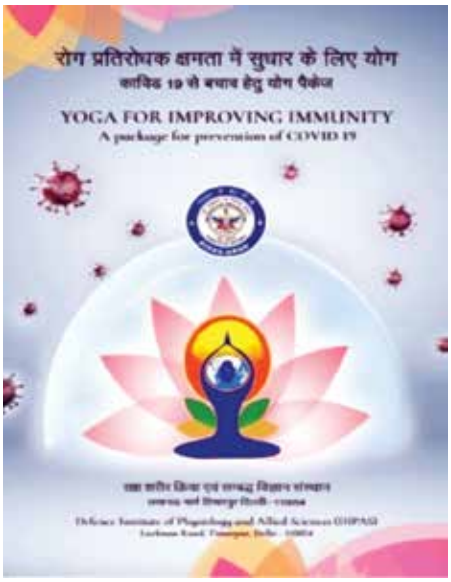
Yoga Package for Improving Immunity

In the wake of outbreak of COVID-19, the whole world is reeling under a state of fear and anxiety. Patients with poor immunity, obesity,

preexisting cardiovascular disease, hypertension and related conditions are more susceptible to the pandemic. Besides symptomatic management and supportive therapy, there is no specific antiviral drug in line for the treatment of COVID-19 as of now. It is a well-known fact that prevention is better than cure. Therefore, by improving functional capacity of physiological systems with special reference to enhancing the innate/ acquired immunity, one can maintain optimum health and performance in this time of crisis.

Regular practice of yoga can increase both the arms of immunity—the humoral and cell-mediated at rest and in response to vaccination—and reduce the markers of inflammation. Yogic practice helps to improve innate immune system by increasing concentrations and expression rate of human beta defensin 2 (HBD-2), an antimicrobial peptide in innate immunity that provides a biochemical barrier by exhibiting anti-pathogenic activity and also decrease the concentration of nuclear factor kappa-light-chain-enhancer of activated B cells (NF-κB). An increase in immunoglobulin A (IgA), a first line of defence against pathogenic microbial invasion of the human body is reported. In a study it was observed that regular practice of yoga can improve lung function and capacity, had beneficial effects in allergic rhinitis and cytokine profiles – IL-2 levels. Yoga practice also significantly increases immune-related cytokines, such as interleukin-12 and interferon-γ.

It has also been reported that serum levels of glutathione peroxidase and oxidized glutathione significantly decreased whereas activities of superoxide dismutase, glutathione S-transferase, glutathione reductase, reduced glutathione and total antioxidant status remarkably increased after yoga practice compared with the control



Yoga Package for Immunity Improvement

group. Practice of yoga can also help in the repair and regeneration of tissues by inducing stem cell trafficking from bone marrow to the peripheral blood. Stress, anxiety, loneliness and depressive feelings that may be generated at the time of crisis has been reported to reduce chronic inflammation, enhance immunological memory in the context of vaccination and even reduce the number of sick days associated with the common cold and other upper respiratory tract infections. Scientific publications also reported that yogic practices can calm down mind to get rid of all kind emotions, depression, anxiety, stress and better mental function. Yogic controlled breathing, pranayama, is very potent to improve immunity and helps to manage anxiety and stress. Regular yoga practice can also change autonomic balance towards more parasympathetic,which helps the practitioner to stay in a relaxed state of mind and helps in the process of regeneration. Parasympatho-dominance can also increase the resilience of the practitioner to face challenges and mind becomes focused and still. Studies also showed that regular yogic practice can increase the baroreflex sensitivity, decrease the release of stress hormones, cortisol and adrenocorticotropic hormone (ACTH) and increase the release of serotonin, dopamine and brain-derived neurotropic factor (BDNF). Yoga can also increase the activity and number of natural killer cells, CD4+ and CD8+ T-cells, which play a major role in the cellular defence mechanism against pathogens.

DIPAS by incorporating selected yogic suddhi kriyas (for cleansing), asanas, pranayamas and meditation, has formulated a yoga package with the aim to increase the immunity, lung function and overall health of a person. This yoga module might be helpful as a preventive measure to check respiratory distress as observed in Corona affected patients.

The Way Ahead

The tasks of soldiers are likely to get more and more complex with advancement of technology with each soldier required to perform multi tasks at a time with highest degree of accuracy and precision under global environment. Maintaining highest level of cognitive and physical performance will be possible using integration of modern technology (genomics, proteomics, trancriptomics, nutrigenomics, etc.), nanotechnology and system biology. Efforts are being made to develop predictive markers of acclimatization, performance and screening of suitable individuals for specific tasks/missions with respect to their working environment. Recent pandemic of COVID-19 confirms necessity and urgent need to protect soldiers and citizens from biological warfare agents that can be devastating and research in this area will be the main focus of life science laboratories including DIPAS.