Review Article

High altitude parachute operations - Aeromedical considerations

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High altitude parachute operations are practised by most modern armed forces. Such operations are usually High Altitude High Opening (HAHO) jumps or High Altitude Low Opening (HALO) jumps. Each of these types of jumps have important aeromedical implications for safety of the man and success of the mission. This paper reviews the aeromedical considerations of such operations with reference to selection and training, pre jump requirements, actual parachute operations, oxygen system requirements and medical support for such operations.

Keywords : Parachute operations, High altitude, HALO jumps, HAHO jumps.

After World War II, the availability of highly specialised air defence systems have far outstepped the ability of a large transport force to evade them. None-the-less, with the developments of the equipment and techniques it is now possible to undertake a single aircraft sneak mission and drop small groups of battle ready soldiers from extremely high altitudes. They then either free fall to low altitudes or manually open the high performance canopies at the point of drop and fly to distant destinations. This military form of skydiving is called Combat Free Fall Parachuting. "Winged Flight" from high altitudes offers another potentially clandestine method of delivery of special force units into enemy territory often covering a stand-off distance of upto 20-25 km. The open-ended cell construction of the Ram Air Canopy, which such units may incorporate, imparts it with true aero-dynamic capabilities, and a glide to descent ratio of 3:1 with a forward speed of about 22 knots. Aerial reconnaissance or artillery spotting by a team of paratroopers from just inside the border, avoiding radar detection, is also a possibility. A tandem backpack of square main and reserve ram air parachute is used for high altitude combat free fall parachuting.

High Altitude High Opening (HAHO) and High Altitude Low Opening (HALO) combat free fall techniques from altitudes of 9,144-10,668 m are the current combat parachuting techniques being followed world wide.

Aeromedical concerns and personal protection.

In 1945 Lt Col William Lovelace at Wright Field USA was the first physician to undertake a study on aeromedical aspects of operations of parachutes at high altitudes. At an altitude of 12,252 m, he encountered a temperature of -70 deg C and was within 10 seconds of death, but was saved due to the supplemental oxygen he had carried. The extremely high canopy opening shock "drove

the breath from his lungs and consciousness from his mind.' It ripped away the leather glove causing injury to his left hand. At 6096 metres he regained consciousness and landed in a wheat field suffering from 'oxygen starvation' 'severe shock' and he had a 'frost bitten' left hand [1]. The physiological costs of his experiment continue to be the basis for aeromedical concerns of high altitude parachuting even today.

These aeromedical aspects are discussed under the following broad headings:

* Selection and ground training
* Pre-jump considerations.
* High altitude parachute operations.
* High altitude parachute oxygen requirements and equipment.
* Medical support and action

Selection and ground training

A night time mission of paratroopers jumping from very high altitudes is associated with tension, abandon, loneliness and continual and unconditional readiness to risk one's life. The whole process of a para - drop requires bursts of concentrated energy. Studies have shown that parachute opening i.e., time of ripcord pull is clearly the time of greatest tachycardia [2]. Maintenance of stability and control during free fall requires fine adjustments of body position. The total muscle work done during free fall, with full combat equipment, is high and essentially isometric. In addition, most injuries in parachuting are orthopaedic in nature and occur during landing. Foreign studies have reported injury rates of military and sport parachuting to vary between 0.14% and 0.22% respectively [3]. Therefore demands of physical fitness and psychological stability for combat free fall are high and proper selection and ground training are of prime importance.

Presently candidates for combat free fall are drawn from experienced army paratroopers. Prior to induction into training for HAP operations, these men undergo Decompression Chamber Testing. Successful completion of a simulated hypoxia profile to a maximum altitude of 10058 metres with 30 min prior de-nitrogenation is mandatory. The first part of such decompression testing runs includes an ear clearance test where correct performance of valsalva manoeuvre is demonstrated. Though these personnel report for aeromedical fitness testing only, a short lecture on the aeromedical aspects, first aid and personal protection is also given to them.

Pre jump considerations

Self imposed stresses : In addition to normal mission planning, supervisors need to pay due attention to factors exaggerating the effects of altitude exposure. These include fatigue, improper diet, poor physical fitness, alcohol and tobacco use and all of these are likely to increase in an actual combat scenario. Rising earlier than normal in the morning causes the greatest drop in performance. To avoid fatigue during training, personnel need to be rotated so as to obtain enough sleep and rest. Simple sitting exercises can reduce fatigue by stimulating circulation and relaxing muscles. These also help in preventing parachute opening and landing injuries [4].

Coordination with aircrew and emergency escape: Military transport aircraft offer a

safe means of transportation and a stable jump platform for the parachutist. However, there is always a chance that an emergency exit from the aircraft may have to be undertaken. Since majority of parachutists are army personnel, making a decision to bail out of a disabled aircraft on the ground or egress from an aircraft following a forced landing must be calculated, briefed and practised as an exercise specific to the type of aircraft.

High altitude parachute operations

A combat free fall paratrooper is sequentially exposed to diverse temperature conditions during a single jump. These include the pre-embarkation conditions on the ground, the relatively comfortable and controlled confines of the aircraft, and the extreme cold of high altitude with temperature of -55°C at 30000 to 40000 feet altitude [5]. High altitude operations (especially HAHO) require the jumper to dress for prolonged exposure to the outside cold environment. The clothing includes inners, overall, shoes, goggles, gloves and helmet. However, the many layers of warm clothing and extra equipment are not conductive to heat exchange inside the aircraft. Additionally, perspiration greatly increases the chances of frost bites and hypothermia upon exposure to altitude. A possible solution to this paradox is to advise the jumpers to wear optimally layered protective clothing depending on the ambient conditions. In addition aircrew should be advised to keep the cabin as cold as possible. During free fall from 35000 to 40000 feet altitudes, the air density is low and the component of drag is small therefore the true air speed at terminal velocity is high, reaching about 100 m/sec. Expert free fall parachutists take advantage of the high air flow to achieve controlled free fall by repeatedly modifying the position of their limbs. During a dive, vertical speeds can reach upto 200 kmph, creating a strong dynamic pressure head. Properly secured clothing and use of goggles and helmet to protect the eyes and ears is an essential requirement. Low air density and a high terminal velocity are also liable to generate very high parachute opening shocks (POS) [5]. However the design of the ram air parachute incorporates a slider reefing system which prolongs the canopy deployment time and reduces the POS to within tolerable limits. At the same time the high descent rates of the canopy deployment can be reduced near the ground by using the control toggles as air brakes to stall the parachute. The jumper is able to achieve a near stand up landing, thus minimising landing injuries.

Oxygen requirements and equipment

Oxygen equipment is an integral part of high altitude parachute operations. It consists of pre-breathing equipment for para jumps depending upon the high altitude para operations which require the individual to spend varying amount of time above 18000 feet AMSL, the threshold altitude for decompression sickness. Based on the parachutist oxygen requirement chart, pre-jump de-nitrogenation is resorted to to prevent decompression sickness. 100% oxygen pre-breathing schedule varies between 30 min for altitudes from 18000 feet to 25000 and 75 minutes for operations at or above 35000 feet [6].

The oxygen pre-breathing console is a compact, semi-portable system having

integrated oxygen bottles, flow meters and valve assemblies. The system can support a maximum of 6 personnel at altitudes upto 33000 feet and delivers 100% oxygen to the individual regulators. This unit also serves to prevent hypoxia in flight when the cabin has been depressurised. It is secured at a convenient point on the floor of the aircraft and the individual hoses are routed to the seated users. At the 2 minutes pre-jump warning the individual turns on the oxygen from the bail out bottle and disconnects the pre-breathing hose, avoiding any break in the de-nitrogenation process.

The bail out oxygen bottles consists of two 868 cm^3 high pressure oxygen cylinders connected in tandem and charged between 1800 - 2500 psi. These are held in a pouch which is strapped on. The cylinder mounted regulator - pressure reducer provides a constant flow oxygen to the face mask via an economiser unit. This system has an operating range of 0 to 35000 feet and can sustain an individual for about 45 min. The manual operation of the system allows the user to 'switch -off' supplemental oxygen after he has descended to below 10000 feet altitude.

Medical support and action

It is the policy in some western countries for a physiological observer having good knowledge of aviation medicine to accompany in all air dropping flights above 5486 m. Their duty is to monitor the pre breathing apparatus and deal with any emergencies/ oxygen equipment malfunction in flight. It is now suggested that trained medical officers and medical assistants be incorporated into the high altitude combat free fall parachuting team to undertake in flight medical monitoring.

The suggested actions for the medical team are :

Pre - Flight

(a) Briefing on aeromedical aspects, especially hypoxia, decompression sickness, ear clearance procedures, oxygen use.

(b) Pre - flight medical examination

(c) Administration of nasal sprays if required.

(d) Assist in donning of helmets / masks and advise on protective clothing.

(e) Pre-flight inspection of on-board oxygen system.

In - Flight

(a) Hook up all crew on oxygen as per mission requirement

(b) Start pre-breathing when aircraft is above 457 m

(c) Monitor all paratroopers for any physiological effects.

(d) Follow the time warning prior to bail out.

(e) Check change over to bail out oxygen.

(f) Assist in exit.

Post Flight

(a) Continue oxygen for inflight personnel till below 3048 m

(b) Post flight check of paratroopers especially for delayed otitic barotrauma/delayed decompression sickness and injuries.

Conclusion

Combat Free Fall parachuting involving HALO and HAHO is a specialised branch of para jumping requiring a fully fit mind in a fully fit body. Like flying, it is unforgiving in even the slightest moment of human error or equipment malfunction. The aviation medicine specialist has a vital role to play in developing and maintaining the life support equipment and training the paratrooper to maintain a high level of physical fitness and combat effectiveness.

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