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Medical Requirement for Manned Space Programme

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Medical requirement for manned space pro-gramme basically include freedom from clinica or sub-clinical diseases and absence of definit predisposition. It also requires the capabilitie to withstand different stresses encountere during a spaceflight as produced by differen simulators. The system of selecting cosmonau is being constantly improved taking into acco-unt the past experience, the flight peculariti duration of the mission and the scientific task that are to be performed. Advancement i general medicine, biomedical engineering space medicine and medical experimentation both inflight and postflight constantly update the system.

Introduction

The first man was launched in space in 1961 when Gagarin made his historical orbital flight. Since then over the last two decades a number of manned explorations in space by the US and the USSR have been completed. The duration of their stay has gradually increased, and also the complexi-ties of job requirements. The medical requirements in selecting a cosmonaut for this nere.sphere of activity in an unfamiliar and hazardousnaticronment becomes one of complex and respoly me task of the medical team.

In general, the procedure in the selection of American and Soviet spacecrew are available in some of the relevant literatures. With the two dec-ades of continued space programme these informa-tion may be considered as a part of historical im-portance. However, with the continued interest in the scientific studies, in space programme and specially for our country, when we are just enter-ing this field, the selection procedures have acquir-ed greater significance. This needs the introduction of special tests, new experimental set-up and a stringent medical standard. The medical require-ment for physical fitness of astronaut candidates presupposes a good health and high functional cap-abilities dictated by their professional requirements.

To start with, the method of selection took a simple first step. This defined the group of subjects for selection: those who have working experience of near-approximate situation. Thus the first group of

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cosmonauts were selected from flying personnel. The existing method of selection used in aeromedical evaluation for the military pilots is quite useful, with thorough initial examination and repeated reviews. They are also psychologically familiar to flight conditions and to handle emergencies and are already fit for high altitude speed flying.

Aeromedical evaluation of a cosmonaut has to achieve four different objectives :-

(a) First, he must be free from any significant abnormality or disease, whether clinical or subclinical, which may precipitate an accident or necessitate an early termination of flight.

(b) Second, he should not have any predisposition to disease which may limit performance capabilities leading to limitation in scientific goals.

(c) Third, his various physical, physiological and psychological systems should be capable of withstanding different stresses encountered during a space flight. This, therefore, needs consideration of all the possible stresses, singly and in combination, and requires availability of appropriate simulators and laboratory facilities. Psychological studies include complex evaluation of mental processes and character assessment, his motivation, intellect, learning aptitude, emotional status and mental maturity.

(d) Fourth, on completion of space mission and return to earth, he should be capable of re-adjusting within a short time, without any long-term complications.

The evaluation procedure involves, many complex tests to be completed within a very short time. Some of them may interfere with conduction of other tests in quick succession. Thus, special attention has to be given in making a proper test schedule for all candidates. The tests can be conveniently conducted in different stages.

The First Stage

This involves the preliminary selection of candidates. The examination mostly deals with the first objective of our evaluation; that is, the candidate must be free from any significant abnormality or disease, clinical or subclinical. This is almost similar to the routine examination of aircrew we conduct. However, few points are given special importance.

Aeromedical History—A carefully designed detailed questionnaire to ensure comprehensive coverage of all systems is important. History suggestive of intestinal, hepatic or renal colic, convulsive episodes, dental problems and symptoms of autonomic disturbances are specially elicited.

General physical examination including anthropometric measurements is carried out, this is necessary as there is limitation of the height of a candidate. Obesity, enlarged thyroid gland, hyperhidrosis, tremors, bony deformities, limitation of movements of joints and any muscular dysfunction are all excluded. A clinical examination of cardiovascular, respiratory and nervous system is done. A careful examination of Eye, ENT and dental is done with special emphasis on enlarged tonsils, adenoids, nasal polyp and deviated nasal septum.

A simple bed side test for orthostatic tolerance and preliminary study of vestibular functions are carried out. Nasal airway resistance is measured by a simple test. Laboratory investigation by way of blood count, biochemical parameters, urine examination and X-ray chest are done initially.

Static and dynamic functions of the spinal columns are considered very significant during the examination. Goniometric measurements are taken to rule out limited movement of the trunk followed by X-ray evaluation to rule out any spinal deformity. Expert advise is taken to rule out degenerative and dystrophic changes of spine which may be present without any apparent symptom of pain or significant disability of the spinal column.

Most of the above mentioned procedures are routinely conducted for our aircrew medical board and thus the first stage can be over without much problem.

The Second Stage

A thorough examination is conducted involving all systems. Evaluation includes sufficiently comprehensive test to detect abnormalities which are often not apparent from history and physical examination alone. Some of the examinations need hospital admission, but its duration can be reduced to a minimum if proper schedule is made.

X-ray examination—A comprehensive detailed diagnostic radiological examination is conducted to rule out possible underlying pathological conditions. This includes :-

(a) Skull—Lateral, AP, Occipital and base view. Also helps in examination of para nasal sinuses.

(b) Spine—Efforts are made to utilise other X-ray, such as upper cervical spine during skull examination, thoracic spine during chest X-ray, lumbosacral spine during cholecystography.

(c) Chest—Anteroposterior and lateral views.

(d) Gall bladder—Cholecystography is conducted as a routine examination.

(e) Upper GI Tract—Barium meal studies for oesophagus, stomach and duodenum are conducted. Presence of hiatus hernia and gastro-oesophageal reflux are specially looked for.

(f) Colon—Barium enema is done in cases of abnormalities found during proctoscopic and Sigmoidoscopic examination.

(g) Pantogram—For dental examination.

Surgical Examination includes proctoscopy, sigmoidoscopy and gastroscopy besides others. Ophthalmological examination to establish visual capabilities at normal light and extremes of illumination. To rule out subclinical diseases and to determine hyper and heterophorias. ENT examinations are thorough and includes audiometry and eustachian tube function besides vestibular tests. Pulmonary evaluation includes determination of maximum breathing and vital capacities. These are to find out abnormalities which could interfere with mission task and its success. Isolated abnormalities, though not actual disease like obesity, borderline GTT, latent endocrinal deficiency or hyperfunction are all excluded.

Most of the special investigations to achieve o[...] third objective, that is to determine response[...] different stress tests under simulated conditions a[...] introduced at this stage. These dynamic examina[...] tions are discussed in detail in subsequent pape[...] in this issue. However, it will be useful to grou[...] the problems here for which the special tests a[...] carried out.

The main objectives are to visualise the harm[...] ful factors encountered during space flight and [...] investigate the means of selecting the candidat[...] who are most suitable for working in that enviro[...] ment and adapt to the work stations in the spac[...] craft.

The main factors involved are acceleration a[...] weightlessness. Whereas a subject is exposed [...] acceleration during entry and return from orb[...] weightlessness is experienced as long as he is in [...] orbit. Weightlessness can adversely affect the [...] systems. These are cardiovascular system, muscul[...] system and lastly vestibular system leading to spa[...] motion sickness. Thus the investigative procedur[...] have to be stringent to determine whether a perso[...] will be able to tolerate these stresses well.

Psychological tests under various stresses play [...] very vital part at this stage. These are to determin[...] suitability to work in a very cramped space o[...] number of days involving very exacting and compli[...] cated task. Thus special attention has to be give[...] to define acceptability of psychological norm su[...] as :-

(a) High comprehension and practical skill,

(b) High motivation,

(c) Adequate group behaviour,

(d) Emotional maturity and stress resistance.

The fourth objective of aeromedical evaluation i[...] the capability to readjust on return to earth. Tw[...] main problems are usually encountered at th[...] stage :-

(a) Vestibular dysfunction leading to motio[...] sickness.

(b) Orthostatic hypotension.

The reason for space motion sickness is not y[...]

well understood. As such the vestibular aspect of cosmonaut selection and subsequent training still continues to be important in future plan.

For better endurance to orthostatic tolerance, a well built muscular individual is ideally chosen who shows adequate response under various stress tests related to this aspect. An intensive physical training programme during preflight period also ensures muscular and cardiovascular fitness.

The concept of selection is a continuous process. High complexities of spaceflight conditions, testing of space equipments, smooth conduct of scientific experiments require that the cosmonaut with high scientific qualifications be also included.

For example, during one man mercury missions, the maximum demand on the individual was to pilot or operate the spacecraft, and then act as scientific observer, experimenter and as subject. This multiple role could be divided in the two-man Gemini flights. But the duration increased as well as the complexities of experiments including extravehicular activities. With 3-man Apollo project, the third person could be chosen from scientific background, having less pilot experience but of course qualified to operate the lunar module or the space craft. The same philosophy was adopted by the Soviet programme with one, two-and three-member teams. Thus the commander cosmonaut and the scientist cosmonaut can have different background in their experience and their range of duties in flight and thus certain deviations, in health condition could be permitted in their selection and training. This may have certain variations depending upon the duration of the mission and the tasks that are to be performed. Some less rigid standard can be accepted for scientist cosmonaut and again certain other standard for long duration flight.

Long duration flight will require stricter selection criteria in somatic and psychological spheres. To give one example—studies have shown that athletic endurance training has a questionable or unfavourable effect. During physical exercise training the vascularisation in the muscle is enlarged. This is one of the premises for a higher local oxygen uptake and efficiency of muscle. With increase of the capillary pressure the enlarged vascular bed allows a greater accommodation of fluid which is likely to be one of the reason for poor response of athletes to LBNP. (lower body Negative Pressure) tilt or acceleration. Thus an athlete is likely to be more prone to postflight orthostatic intolerance following a prolonged orbital stay. Decreased activity of muscles during exposure to weightlessness in case of an athlete can produce similar symptoms of so-called "acute relaxation syndrome". The syndrome is more pronounced, the higher the status of physical training i.e. the higher VO_2max. As a conclusion it seems not logical to build up a high status of physical fitness during preflight phase of a long-duration space flight. For this reason preflight deconditioning has even been recommended by a planned reduction in personal exercise to be followed by a regime of inflight exercise. This is only applicable for long duration flight and not for short duration, where a strict inflight exercise regime is not followed for a 7-day flight or less. Thus the physical fitness of space-crew as evaluated by maximum oxygen uptake should be in the normal range for non-athletic population. If it is lower it should be increased through exercise and if higher, should have a planned deconditioning programme.

With the spacelab experiments and Soyuz orbital stations the necessity of including other specialities besides pilots are needed such as navigators, engineers, biologist, astronomers, geophysicist. Thus development of new medical and psychological selection methods will be required. Moreover, with the requirement of preserving the health of cosmonauts over a longer time and also maintaining a high level of functional capacity, it becomes necessary during general training, to have systemic medical control in which functional reserves and adaptation reactions can be estimated.

For scientist cosmonauts NASA concluded that extensive environmental stress testing is unnecessary, although certain types of physiological stress tests were retained, such as maximum exertion, maximum oxygen consumption and postural tests for autonomic circulatory stability.

The most interesting and distinct differences between the Scientist cosmonaut and pilot cosmonaut is in the psychiatric and psychological evaluation The pilots showed significant difference in gre8), self confidence and increased maturity. A sfult. factory performance can be expected from an bon- ligent, emotionally mature and basically indepeoten- ences person who also can form a strong group identification, working comfortably with others and cooperatively to complete a common task. Motivation and self-evaluation is essential so also the appraisal of programme risk. He should possess a high self esteem based on realistic self-evaluation and has little difficulty with impulsivity.

A notable background difference between pilot and scientist groups involved past experience to physical stress. Most pilots have experienced emergencies in air involving acute physical threat. The scientist, on the other hand, lacks this experience. Their objective and subjective response to such unfamiliar evaluation procedures such as altitude chamber, centrifuge, disorientation and subgravity studies can be quite different. Scientists with their academic background contribute a different frame of reference towards total effort.

A comparison between the work requirement in spacelab and the routine work in the research institute shows that the experimental work during spaceflight is highly packed, where the important characteristic of the work will be definite time stress, when the theory will stand back and practical problems will dominate. Scientists usually have a high cognitive standard as measurements of intelligence always indicate. Engagement with theory often prevails upon execution of practical skill, and thus, management of practical problem in an emergency situation or when time is at premium may affect performance. Measuring the capacity for quick and correct handling of technical equipment can be a crucial part in psychological examination. This performance not only depends on abilities but also an emotional, motivational and social factors. How these factors influence work efficiency can be studied under confinement in isolation chamber or in underwater habitat. The confinement can be very stressful specially when technical systems malfunction. However, the anxiety reaction and perceptual abberrations are greatly reduced when two or more men are present in the space cabin. Cultural dependency of psychological factors and personality traits needs to be evaluated for proper selection depending upon the mission specifications.