Aging and Space Travel

STANLEY R. MOHLER, M.D.

THIS PAPER deals with the matter of aging and its relation to space vehicle crew members undertaking prolonged lunar and trans-lunar space missions.

The Mercury Astronaut program imposed an upper age limit of forty as one of the selection criteria for candidates.[18] The background of training and experience required of the Mercury astronauts automatically set a lower age limit somewhere in the latter twenties.

Two decades from now, when prolonged manned space probes begin to become relatively common, it may prove expedient to include some non-pilot space crew members whose ages may considerably exceed forty. There are many reasons why this is likely, one being the high degree of specialization increasingly required for full mastery of the many complex subsystems comprising the space craft.[4,12] Also, the most highly motivated and most capable individual available for a given position on a given mission, may be in his fifth or sixth decade. This may particularly be true if the mission requires an astronomer, exobiologist, or geochemist.

What, then, in consideration of our present level of knowledge concerning the aging process, and its attendant potential infirmities, can we now anticipate to be special problems in what might be called astrogerontology? What assets are likely to be brought by older crew members to the realm of space travel?

Following several months or longer under attenuated gravitational forces, or in a state of weightlessness, the cosmonaut will find the return to one G life quite stressful.[19] This will be particularly true for the older cosmonaut. Striated muscle intracellular myofibrils will have to be multiplied, a process which occurs more and more slowly as the adult ages.[11]

The partially demineralized skeletal frame, having acquired osteoporosis secondary to diminished mechanical demands, will have to be reconstituted through graded exercise, dietary or parenteral calcium, magnesium, phosphorus and fluoride containing salts, and amino acids and vitamins. The older the skeleton's host, the less rapid is the remineralization of the bone.

Julius Wolff, in 1868, made an observation which has become known as Wolff's Law.[13] This states that "Every change in the form and the function of bones, or in their function alone, is followed by certain definite changes in their internal architecture, and equally definite changes in their external conformation, in accordance with mathematical laws." This law will have remodeled the entire supporting skeletal frame of the space traveler, and weeks to many months will be required to reform the skeleton as an effective operational one G structure.

It must be remembered that many of the joints must work with micrometer precision, particularly those in the foot and ankle. The space travel remodeling of the skeleton will have produced certain alterations in the joint faces, and if a sudden and sustained imposition of one G is brought to bear for too long upon the remodeled joints, irreparable damage will occur. Many joints are foci for pressures of several hundred pounds when quick motions or moderately heavy lifting is carried out (especially those in the ankle, knee, hip, lumbar spine and pectoral girdle).

Rehabilitating and reconditioning the older person to one G will prove more time consuming than will be the case with the younger per-

Doctor Mohler is Director of the Civil Aeromedical Research Institute, Federal Aviation Agency, Oklahoma City, Oklahoma.

son. All persons will experience some muscle atrophy in environments having a gravitational force of less than one G.[6] However it should be emphasized that a great deal of individual variation on this matter will exist. The older person who initiated his space voyage in good physical condition from the athletic standpoint, and who has a life history of maintaining reasonably good physical condition, will be a better candidate for terrestrial rehabilitation. Fat tissue should be kept at a minimum during the space voyage, and some type of spring exerciser should be employed for all major muscle groups during the trip.

Tied in with the individual variation matter, is the factor of genetic endowment, wherein some older persons will simply have constitutions which provide what can be called, for want of a better term, good "tissue vitality."

The ligaments and tendons will become somewhat attenuated under diminished gravity. There will be a tendency for the subluxation of certain joints following return to earth, particularly in older persons if stressful physical activity is undertaken too soon.

Joint cartilage shows some degree of irreversible wear and tear in most older persons. Therefore, the older cosmonaut, upon return to one G conditions, must receive special attention relative to the reconstitution of his cartilage. Adequate time must be allowed for the synovial membranes to respond to the increased demands placed upon them for joint lubrication. Perhaps information on this factor, and other factors, may be obtained by extrapolation, through studies of animals shifted for prolonged periods to environments where more than one G force prevails.[21]

Inherent in all of these musculoskeletal connective tissue readjustments, is the matter of tissue nutrition. Shut-down capillary and lymphatic bed segments will have to be reopened. The endothelium of long-dormant micro-vessels will have to be revitalized. Of special significance here, is the myocardium, which will very likely have developed a degree of atrophy secondary to the reduced demands under near-weightless conditions. A similar atrophy of the postural muscles will lead, shortly after return to earth, to malaise and general fatigue, until adequate reconditioning has occurred. This will be particularly bothersome for older persons.

The reactivation of capillary and lymphatic beds in atrophic muscles will be complicated by the aging process, which, in some as yet ill-defined fashion, diminishes the vascular system's capability in this regard. Furthermore, chronic exposure to low levels of ionizing radiation, a certainty of prolonged space travel, produces distinct irreversible damage to vascular endothelium.[1,15,16]

With regard to the neurophysiologic and psychologic aspects, the middle-aged and older individual, by and large, will have the advantage of a diminished desire for sexual activity. Furthermore, since most of the persons over 45 have completed their procreational roles, the risk of passing any radiation-induced genetic defects to future generations is markedly diminished. For the post-menopausal female space traveler, menstruation will be no hygienic problem, and no hormonal preparations for the suppression of menstrual flow will be necessary (menstruation could lead to excessive iron loss on prolonged trips, a matter which must be given careful consideration).

In general, an increased tolerance of monotony accompanies aging.[14] Older persons are more frequently better suited to prolonged tasks which involve routine manipulations.[20] The older person may prove to be better able to withstand sensory deprivation. Cultural and personality factors play a role here, of course. We must await space simulator studies before we can pull this information together relative to space travel.[6]

It has been observed in industry that older persons tend to place an increased value on the precision of performance, rather than on the speed of performance.[2] This certainly has implications bearing upon the quality of a given task.

On the negative side, the older person is less tolerant of "time-pressure" tasks, particularly if such tasks are relatively new to him.

Furthermore, by virtue of having had longer experience in general, more alternative solutions to a given new problem are apt to occur to the older person, with the result that he suffers a "time-lag" in deciding upon which of the several possible solutions is preferable.

The presbyopic eye, with its far out "near-point," is a distinct disadvantage to the older cosmonaut who must move in confined quarters. This and other factors have been assessed for driving and flying.[7,10] Shock-resistant spectacles with hardened plastic lenses will be a must. On the other hand, the older eye, with its physiologically yellowed lens, is less susceptible to dazzle under conditions where blue or green light predominates.[8]

Up to the mid-sixty age range, in the context of this paper, hearing, graviceptor sense,[17] and other neurophysiologic functions, including reaction time, should not have changed enough through aging to interfere with the functions of the non-pilot members of the space crew.

From the group dynamics standpoint, relative to small groups undertaking prolonged missions under conditions of extreme group isolation, the older person can exert a distinct stabilizing effect upon the group as a whole. The older person's past history and longer occupational experience,[3] provide an opportunity for a more complete assessment of the manner in which he, as an individual, handles his aggressive and hostile feelings. His reactions to emergencies and his particular emotional outlets can be more fully estimated.

Little has been said here of pathology. Clinical coronary artery disease is most frequently first discovered in the fourth to sixth decades. It can be anticipated that within the next five years, the sufficiency of coronary blood flow and myocardial irrigation following each heart beat will be a matter readily determined in a given individual on an outpatient basis. The test will possibly involve the use of a bolus of fluid containing radioactive material. Also, perhaps within the next decade, an immunologic test for covert neoplastic conditions will be perfected.

The above discussion covers a broad spectrum of considerations in the field of aging. As of January, 1961, the National Institutes of Health was supporting 700 research grant projects in the field of aging, ranging from studies of the biologic aspects, through disease processes, to behavioral aspects.[22] In addition, 100 intramural research projects in aging were underway at NIH during 1960. These 800 projects are supported at a level in excess of 16 million dollars. It can be anticipated that certain of these projects will develop information pertinent to space medicine.

A final point here, with regard to time dilatation and space travel, is that although a certain slowing of the biologic clock apparently can be expected at higher velocities,[9] the greater velocities, if sustained over longer distances, will necessarily entail an increased exposure to ionizing radiation. The effectiveness of the shielding will become attenuated, and it is quite possible that the gains in longevity through time dilatation, will be more than offset by the tissue damage caused by the radiation.[5]

SUMMARY

Sooner or later, in the evolution of space travel, persons in the fifth and sixth decades of life will desire to be part of the non-pilot space crew. It is clear that the progressive changes due to the aging process will require special consideration when the older space traveler returns and undergoes terrestrial rehabilitation.

Following a space voyage, skeletal elements, particularly the bone and cartilage of the weight bearing parts of the skeleton, must be remodeled according to Wolff's Law. The myofibrils of muscle must be reduplicated many times over, and dormant capillary beds must be reactivated.

In general, it can be said that certain assets are brought by the older person to the realm of space flight. These include a greater tolerance of monotony and repetitious manipulations, and a longer history of performance under different conditions.

Additional parameters relative to the aging person and space flight are delineated, including the cardiovascular system, the reproductive system, ionizing radiation and time dilatation.

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