HABER F, HABER H. *Possible methods of producing the gravity-free state for medical research.* J Aviat Med 1950; 21: 395–400.

With the advent of supersonic aircraft and sub-orbital rockets, it was realized that pilots would begin experiencing short periods of a "gravity-free state" (now called "microgravity"). It had been previously theorized that weightlessness would cause neurovestibular disturbances, motion sickness, and disorientation (1). This Classic paper introduced the concept that parabolic flight would produce microgravity that could be used for medical research. It was calculated that a vertical parabola accurately flown by an aircraft with an initial airspeed of 450 mph and an initial pitch angle of 45° would generate 35 s of microgravity, long enough to investigate selected medical problems. The authors emphasized the importance of such research, as "Gravity as a physical factor of environment has the outstanding property of being omnipresent and everlasting. Not a single individual has as yet been away from its influence for more than one to two seconds."

Background and Commentary

The authors were the brothers Fritz and Heinz Haber, who were both assigned to the Department of Space Medicine at the USAF School of Aviation Medicine. They had been recruited from Germany after World War II to immigrate to the U.S. as a part of Operation Paperclip. Fritz Haber, Ph.D., was an aeronautical engineer who worked for Junkers Aircraft in Germany during Word War II, where he designed a piggyback aircraft system similar to that now used to transport the Shuttle on top of a modified 747. Heinz Haber, Ph.D., was a physicist who served as a Luftwaffe reconnaissance aviator during the war and later a teacher at the Kaiser-Wilhelm Physics Institute before coming to the United States.

In 1951, test pilots Scott Crossfield of NACA and Maj. Charles Yeager of the USAF flew a number of parabolic trajectories in jet interceptors (2). Up to 20 s of microgravity resulted from some of these flights. Crossfield reported initial "befuddlement" while Yeager described disorientation. In the same year, the USAF sent out flights with 30 parabolas lasting 15 s each in an F-80E (3). The test subjects did not report motion sickness, vertigo, disorientation, or impaired coordination. Heart rate and EKG were unaffected.

In 1953, the Aeromedical Field Laboratory at Holloman AFB, NM, began a program of parabolic flight research using T-33 and F-89 jet aircraft. Late in 1955, they began using the F-94C, which could achieve a longer period of microgravity. They found that cats in parabolic flight became disoriented and confused unless they were labyrinthectomized (4). In 1955, the Department of Space Medicine at Randolph AFB began parabolic flight research using T-33 (jet trainer) and later F-94C (fighter) aircraft. They found that eating and drinking in microgravity were not troublesome when squeeze-bottles and tubes were used (5) and urination presented no real difficulty (6). However, it was also noted that cats lost their postural righting reflex (7). At the Aeromedical Laboratory in 1958 they began using propeller-driven C-131 transport for parabolas; while it could produce only 10-15 s of weightlessness, the spacious interior made it possible to observe the reactions of unrestrained human subjects, including their coordination, locomotion, and even the ability to walk along the ceiling with magnetic shoes.

In these early parabolic flights, some subjects suffered nausea, disorientation, loss of coordination, and other neurovestibular disturbances, but the majority reported that, after adjusting to the condition, they found it "pleasant" and had a feeling of "well-being." Investigators also concluded that microgravity produced no abnormalities with regard to heart rate or arterial blood pressure.

In the years following this Classic, NASA has flown parabolic flights on various aircraft. In 1959, Project Mercury astronauts trained in a C-131, which was dubbed the "Vomit Comet," although NASA tried to disseminate the name 'Weightless Wonder' for publication. From 1973 through 2004, two KC-135 Stratotankers were used for NASA's Reduced Gravity Research Program. The older airframe has flown more than 58,000 parabolas and is now on display at Ellington Field, near the Johnson Space Center. In 2005, NASA replaced the second KC-135 with a McDonnell Douglas C-9B Skytrain II which is still based at Ellington Field. Today, many nations have parabolic flight research and training programs and parabolic flights may now be purchased from commercial vendors for purposes of both tourism and research.

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