WALKING ON THE MOON – AN INTERVIEW WITH PROFESSOR DR. WALTER KUEHNEGGER

NASA Apollo Resercher.

Figure 1 Professor Dr. Walter Kuehnegger

This interview was undertaken via email by Kirsty Lindsay MSCP BHSc (Hons), MSc Space Physiology and Health Student, Centre for Human and Aerospace Physiology, King's College London in June 2013.

It takes a hardy soul to step into the completely unknown; and yet the astronauts of the Apollo era did exactly this as they prepared to walk on the Moon for the first time. One of the men tasked with finding out the unknown was Professor Walter Kuehnegger, a young researcher and engineer assigned to answer the question '*Can man walk on the Moon?*'
This was done using a number of different simulation methods, many of which were new and untried, at the NASA Langley Research Centre in the 1960s. This interview focuses on his biomechanics research at that time, with the aim of helping young researchers prepare for future planetary exploration missions by sharing his experiences.

As well as carrying out biomechanics research Prof. Kuehnegger qualified as a US Navy astronaut in 1963, although sadly the program was cancelled before he had a chance to fly. He holds a Mechanical Engineering Degree, equivalent to a Masters from Bulme, Graz, Austria (1948) and a Diploma Aeronautical Engineering from BIET, London (1951). Following his time at NASA, Prof. Kuehnegger studied Aerospace Medicine at the School of Aerospace Medicine, San Antonio, Texas, (1964) and became an orthopaedic surgeon working in both the USA and Europe, as Director, Camp Orthopaedic Research Clinic, Michigan, 1969-1972, the Clinical Professor, Division of Orthopaedic

Surgery, Howard University, Washington D.C from 1972-1974, as well as being made a Fellow of the American Academy of Orthopaedic & Neuro Surgeons in 1983. He developed the theory of Pedo-Cranial-Orthopaedics and holds a number of patents for orthotic devices, the most well-known being the Kuehnegger brace used in the treatment of Scoliosis.

KIRSTY LINDSAY: In the early 1960s, before the research programme started at Langley, what were the general expectations of how human would walk on the Moon?

Professor Walter Kuehnegger: The visit of the Northrop life sciences team to NASA-Huntsville covered in part the proposed work of our biomechanics laboratory. We emphasized the importance of investigating the governing parameters for lunar locomotion, lunar physical task assignments and their costs. These seen at the time were:

- *i)* Metabolic rate with
- *ii)* Oxygen consumption
- *iii)* Heat production
- *iv)* Biomechanics analyses

These parameters had to be considered in the determination of the necessary pay-load for Lunar landing.

The general expectations for human locomotion on the Moon at that time were conjectures that man could jump six times as high on earth due to the hypogravity of 1/6 with similar expectations for energy expenditures.

KIRSTY LINDSAY: What obstacles or issues were expected to impede Luna locomotion?

Professor Walter Kuehnegger: The obstacles expected were more in the environment due to the absence of oxygen, water and surface conditions, including the severe temperature fluctuations in the lunar day/night cycle.

KIRSTY LINDSAY: How did you think that your research was going to fit into the wider Apollo Program, considering things like suit and vehicular design, mission parameters and the successful completion of a manned landing on the Moon?

Professor Walter Kuehnegger: In association with the NASA-Experiments for personal sample collection in the desert we concentrated on the design of working tools in the Apollo and Litton space suit, all of which must consider the reduction in tactile feedback existing in pressurized gloves.

The design of all space suits for extra-terrestrial environments should be directed to attain the parameters for optimal energy expenditures, such as in body joint motions and their range of motion.

Distant task assignments should utilize lunar surface vehicles to provide a temporary working station to include the possibility for rest periods, environmental protection and security.

KIRSTY LINDSAY: Can you give a couple examples of the engineering and physiological problems you encountered when designing your experiments, and how your team overcame them?

Professor Walter Kuehnegger: Where to put the simulator. I conducted a brief internal investigation to find the most feasible method of simulating lunar gravity using the existing buildings. The result led to the construction of a lunar gravity simulation facility using the inclined plane technique along the exterior wall of the longest and highest building. A test control centre at one end led to the inclined walkway with the prior location of a specially designed inclined treadmill. The latter made it possible to investigate the physiological parameters under the sustained steady-state condition under simulated lunar-g

A suspension track with dolly was placed parallel over the walkway. Underneath the walkway, a window was placed over the centre test section to accommodate the biomechanics camera. This modified 80mm camera with a rotating disc produced the desired intermittent time exposures to record the movement of body segment targets on the test subject. Also a calibrated corrective grid system adapted to the median sagittal plane via the inclined angle during the trajectory in suspension had to be determined and consequently constructed on the centre test section. This made it possible to realistically investigate the biomechanical changes in the various test conditions. Each investigation was preceded by a 10 minute standing test, serving as baseline to the following horizontal gait patterns:

I. Walking,
II. Loping
III. Running

This was followed by walking up on inclined tracks and steps as well as the ability to jump up and down from different platform heights. Furthermore, all of these tests were performed in the different modes of shirt sleeve, suit-no pressure to suit pressurized. Additionally, the Physical Fitness Index Test – PFI (Balke, 1963) was performed to monitor any possible conditioning of the test subjects.

KIRSTY LINDSAY: Of the four hypogravity simulation techniques detailed by Spady (1970) (vertical suspension, inclined plain treadmill, underwater treadmill and parabolic flight), which do you feel offers the most realistic and useful method of simulating low gravity?

Professor Walter Kuehnegger: *Vertical suspension*: Requires consideration to the placement of body segment mass centres. Simulation of lunar-g would require their suspension of 5/6= 83% of the segment weight and may lead to vasoconstriction in the suspended portion.

The simulation of Martian gravity of 0.39G will require only 0 .61G suspension and may consequently be more tolerable. Nevertheless, the effects of vasoconstriction should be considered, especially under long test durations.

Inclined plane treadmill: Laterally supported body segments will also be subjected to vasoconstriction under the supporting components of the system and should be considered in the evaluation of the test results, especially pertaining to cardiovascular parameters.

Underwater treadmill: Generally considered of value. The technique, however, is restricted to walking. The side effects of hydrostatic pressure variations from foot to torso, as well as the resistance of the media to step length etc. will affect the test results. The underwater simulation in extremely large tanks has been used for microgravity Extra-Vehicular-Activities (EVA) experiments on large space vehicles.

Parabolic Flight: Of limited use due to the hyper-g acceleration , as well as the short term exposure of the investigational period, followed by the hyper-g load in the pull-out. Experiments for Martian gravity of 0.39G will be dictated by a modified Keplerian trajectory. The pilot can use a transparent (Plexiglas) tube containing a table tennis ball and display a red marker for the desired g-level or a more sophisticated g-meter. Elevator and throttle are then used to maintain this condition for the pay load.

Considering a useful method of simulating the hypo-gravity environment; not easy to answer since each one of those mentioned display certain side effects. Their selection depends entirely upon the intended investigation. Thus, the optimal choice for the study of the physiological response will differ from biomechanical investigations. A universal simulator with a high degree of fidelity to satisfy both demands require further search. The term fidelity describes and also quantifies the degree of reproduction of the actual environment.

My concluding comment: The full reproduction of the actual environment can never be achieved!!! Why ??? Because the organic functions within the viscera still remain under the influence of 1g, except for the short time period available during the parabolic flight pattern, which is not sufficient to produce any desired physiological steady – state condition.

KIRSTY LINDSAY: During your research did you focus exclusively on Lunar locomotion, or did you also consider other planetary bodies, such as Mars. If so did these show any biomechanical differences to waking the Moon?

Professor Walter Kuehnegger: We were completely devoted to this subject (of Lunar locomotion) because of the need to determine the logistic support requirements for the Apollo project.

KIRSTY LINDSAY: Which type of simulator was your favourite to be a subject on, and why?

Professor Walter Kuehnegger: The underwater treadmill with the head and shoulders sticking out. The absence of suspension and supports preferred but this method of simulation has restrictions, as already mentioned.

KIRSTY LINDSAY: For you, what was it like watching the Astronauts on the surface?

Professor Walter Kuehnegger: I was looking forward to personal mission as scientist astronaut! I qualified as a US-Navy astronaut on the 14th of May 1963, and being designated a member of space.

KIRSTY LINDSAY: You were involved in the space program almost from the very start, looking back can you tell me about a particular highlight or moment that stands out for you?

Professor Walter Kuehnegger: To see the confirmation of my work, conducted 5 years before the Moon landings. Also having my work as principal investigator with special reference to the locomotion pattern of loping – termed "Kangaroo jumping".

KIRSTY LINDSAY: Considering your experiences in the Apollo Program, what biomechanical challenges do you expect will be encountered on a Mars Mission; will these be the same as the Apollo program?

Professor Walter Kuehnegger: The biomechanical challenges will be similar, but more tolerable for the astronauts due to the gravitational increase from 0 .17G to 0.39G = a 230 % change.

KIRSTY LINDSAY: If you could offer a piece of advice to the aspirating young scientists, engineers and other aviation personnel reading this article, what would it be?

Professor Walter Kuehnegger: The most important advice to any scientific investigation is to search the literature for the present state of knowledge in the selected area of interest. This will serve as the base and starting point. If not, it may later lead to embarrassment for not doing so- this is from personal experience!

References

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