



(19) **United States**

(12) **Patent Application Publication**  
**Talluri**

(10) **Pub. No.: US 2006/0229160 A1**

(43) **Pub. Date: Oct. 12, 2006**

(54) **SYSTEM FOR CREATING ARTIFICIAL GRAVITY CONDITIONS IN MICRO AND HYPOGRAVITY ENVIRONMENTS**

(57) **ABSTRACT**

(76) Inventor: **Srikrishna Talluri**, Farmington Hills, MI (US)

A innovative resistance exercise system that helps preserve an astronaut's bone density, checks muscle atrophy and helps retain postural and gait stability during space missions while increasing neuromuscular activation and enhancing sensorimotor integration is presented. This innovative system comprises of a tight suit that covers the upper torso of the astronaut—from the top of the head to a little below the waist with magnets or electromagnets placed towards the lower end of the suit. When worn by astronauts on a magnetic or electromagnetic flooring (such as a treadmill's floorboard), a force of attraction is exerted on the magnetic end of the suit to create a downward pull that would be spread by the suit onto the muscular and skeletal systems of the astronaut right from the top of the head down to their feet (thereby also loading the vertebrae which extends into the neck region), as the astronaut seeks to keep his/her upright position. The suit may be used in combination with an internally ridged sole directed towards the plantar surface of the feet to stimulate the somatosensory receptors in this plantar surface of the feet. Prior methods of using chords to keep the astronaut in place on a treadmill restrict ease of movement, take a lot of time and do not load the head-neck region. The invention preserves the astronauts' good health longer and helps them function safely and efficiently in space or in the hypogravity of the Moon or Mars.

Correspondence Address:  
**SRIKRISHNA TALLURI**  
**APT # 304**  
**27136 GATEWAY DRIVE SOUTH**  
**FARMINGTON HILLS, MI 48334 (US)**

(21) Appl. No.: **11/221,498**

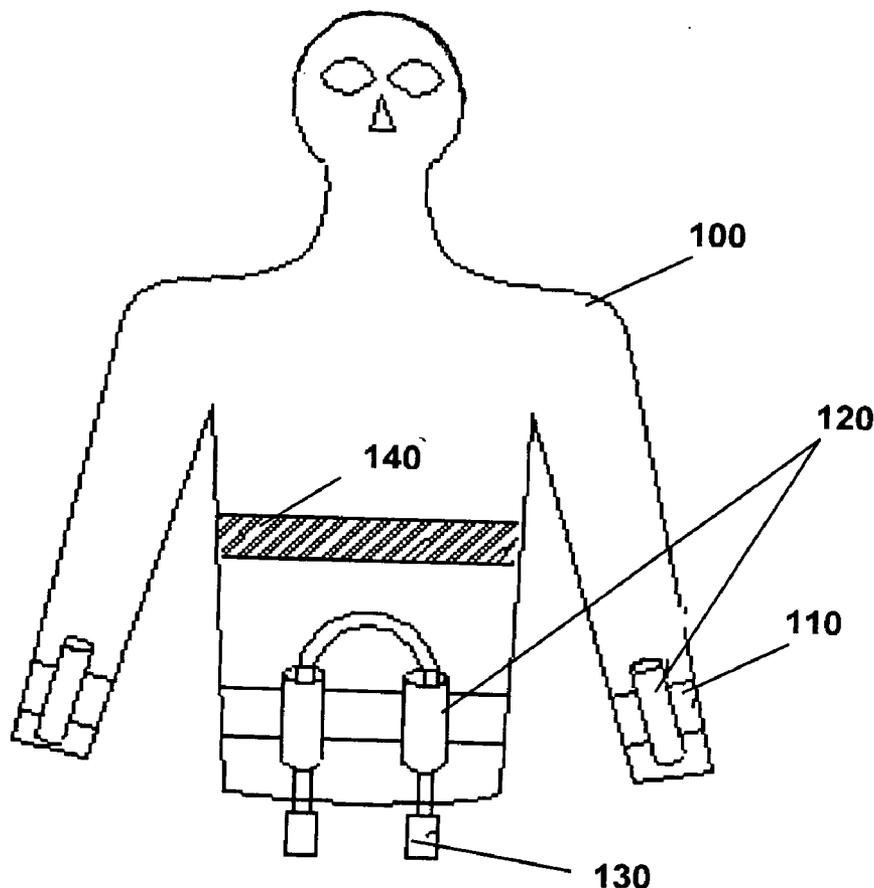
(22) Filed: **Sep. 8, 2005**

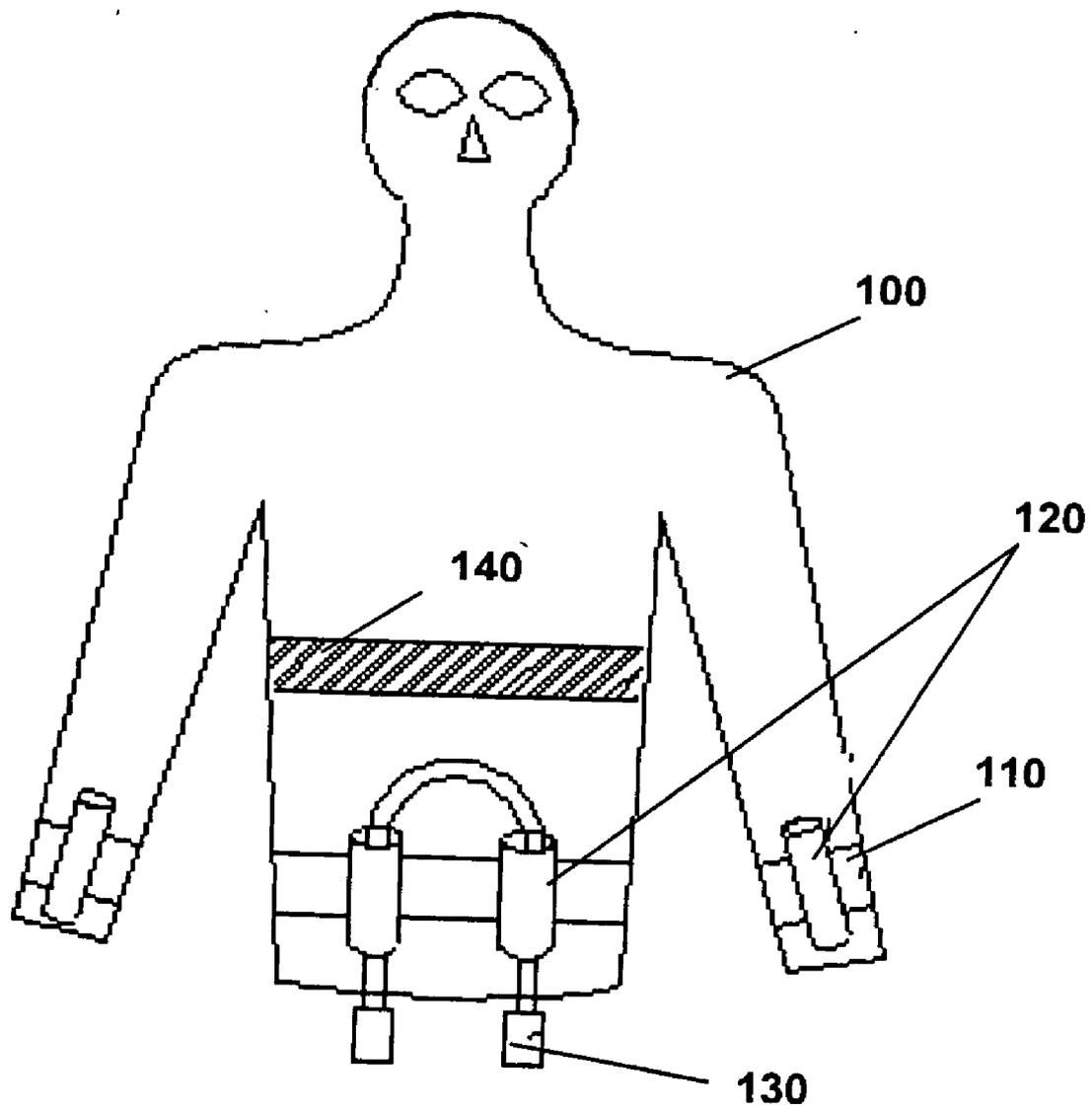
**Related U.S. Application Data**

(60) Provisional application No. 60/607,845, filed on Sep. 8, 2004.

**Publication Classification**

(51) **Int. Cl.**  
*A63B 15/02* (2006.01)  
*A63B 71/00* (2006.01)  
(52) **U.S. Cl.** ..... **482/1**





**Fig. 1**

**SYSTEM FOR CREATING ARTIFICIAL GRAVITY CONDITIONS IN MICRO AND HYPOGRAVITY ENVIRONMENTS**

**CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims the benefit of priority of U.S. Provisional Patent Application Ser. No. 60/607,845 filed Sep. 8, 2004 and entitled "SYSTEM FOR CREATING ARTIFICIAL GRAVITY IN ZERO GRAVITY CONDITIONS", the subject matter of which is hereby incorporated by reference herein.

**TECHNICAL FIELD**

[0002] This invention relates generally to space travel and, more specifically, to a novel and improved method for creating an artificial gravity environment in zero-gravity conditions to counterbalance the detrimental effects of micro/hypo gravity on human physiology.

**BACKGROUND OF THE INVENTION**

[0003] Mankind has created and maintained a presence in space for a few decades now. Voyages into space have become relatively common today and there are space stations that are inhabited by humans, for over a year at a time. Such voyages and continued living in zero or microgravity conditions subjects the human body to physiological stresses not experienced while on earth, where the human body is habituated to and influenced by the presence of gravity. Studies and prior experience has indicated that such long-term exposure to microgravity alters biological processes and detrimentally affects physiological responses in the human body.

[0004] Loss of bone density and muscle atrophy are two major problems. This occurs as the physical stress on the bones decreases and as the muscles are subjected to disuse. They weaken to such an extent that it takes time for astronauts to recover even after coming back to earth and some astronauts' condition, reportedly, deteriorated to such an extent that they had to be carried on a stretcher upon return to earth.

[0005] Countermeasures

[0006] Several different methods of alleviating the detrimental effects of weightlessness exist today.

[0007] Space Fitness Equipment: Treadmills and other fitness equipment such as rowing and bicycle ergometers have been modified for use in space. Astronauts are strapped and bound onto the treadmill or other fitness equipment with elastic chords that generate resistance and thereby simulate the force of gravity. One variation to this basic design of a treadmill with an astronaut strapped by elastic chords is the use of a pressurized treadmill. In this design, the lower body is completely enclosed in an airtight chamber and when air is pumped into the chamber, astronauts feel lighter. When air is sucked out the astronauts feel heavier. By "making astronauts feel heavier in the weightlessness of space the chamber could prevent deconditioning, or loss of strength". The negative pressure in the chamber makes the astronauts "feel heavier and increases their endurance as they workout." (Julianne Remington, www.healthsurfing.com). While the simplest method happens to be regular and rigorous exercise, this takes up a lot of time.

[0008] Electrical Stimulation: There has been research into electrically stimulating the muscles, and hence exercising them. This is a possibility for space travel: "Previous studies have proven the efficacy of Neuromuscular Electrical Stimulation (NMES) protocols that stimulate muscle through skin surface electrodes in order to cause muscle contraction. Although NMES protocols have proven useful in minimizing muscle atrophy, they cause discomfort to those undergoing treatment and are impractical for spaceflight. CSA's Operational Space Medicine (OSM) group conducted a study to investigate a new type of electrical muscle stimulation called Therapeutic Electrical Stimulation (TES)." ([http://www.space.gc.ca/asc/eng/astronauts/osm\\_ems.asp](http://www.space.gc.ca/asc/eng/astronauts/osm_ems.asp))

[0009] Although it is apparently 'impractical for spaceflight', it is still a large part of microgravity remedies—the "Manned Spaceflight and Microgravity" site seems to deem it worthy: <http://www.spaceflight.esa.int/file.cfm?filename=utildestpems>

[0010] Space Boots: Space boots have been designed such that the feet feel as if a reaction force is being applied to them, hence activating all the balancing muscles in the feet and lower body: "Chuck Layne, an associate professor at the Univerisy of Houston, designed special boots that use pneumatic pressure to the feet to simulate the feeling of standing on a floor. The pressure applied to the feet stimulates muscles in the legs, the idea being that this stimulation is akin to a muscle contraction and would thus slow the rate of muscle atrophy. The invention has been tested by cosmonauts on Mir and the results look promising, although the technology is still under development." (<http://www.ibiblio.org/astrobiology/index.php?page=adapt04>)

[0011] Pharmaceuticals: Certain drugs are used by astronomical teams to counter the effect of muscle atrophy and bone demineralization. In particular, amino acids are said to be a useful supplement for preventing muscle loss: "Scientists at the National Space Biomedical Research Institute have used enforced bed rest as a model for both space travel and medically-caused immobility. They find that if subjects who rest in bed for 28 days are given supplements of amino acids, the rates of muscle loss are much reduced. The amino acids are the building blocks of protein and blood tests show how they are taken up by the body to build new muscle." (<http://www.healthandage.com>)

[0012] However, there are important considerations to be taken into account when dealing with pharmaceuticals. It is wrong to assume that the drug will have the same affect on the human body in space as it does on Earth as major physiological changes occur in zero-gravity conditions in space. If research conducted on people who fly airplanes at high altitudes is any indication, drugs can produce drastically different effects when administered in different environments." (<http://www.ibiblio.org/astrobiology/index.php?page=adapt04>)

[0013] Gene Therapy: There is also an interesting process labeled 'gene therapy', that introduces a certain protein, named "IGF-1", into a muscle to stimulate muscle growth and maintenance, thereby minimizing atrophy: [http://space-research.nasa.gov/research\\_projects/spacebiology\\_\\_12-2001\\_lite.html](http://space-research.nasa.gov/research_projects/spacebiology__12-2001_lite.html)

[0014] Nutritional Diet: "While nutrition alone does not cure the conditions that develop as a result of zero-gravity, it certainly helps alleviate the severity of those conditions. It is essential that astronauts maintain a healthy diet despite

their decreased appetites (which are characteristic of people living in microgravity—NASA has found that astronauts eat and drink as much as 70 percent less in space). The body needs all the assistance it can get when fighting infections with a depressed immune system. Good nutrition provides that assistance.” (<http://www.ibiblio.org/astrobiology/index.php?page=adapt04>)

[0015] Pre-Flight Training: “astronauts undergo extensive preflight physical training, building endurance and strength to minimize the effects of muscle atrophy.” ([http://paperairplane.mit.edu/16.423J/Space/SBE/muscle/muscle\\_bckgrnd\\_ug.html](http://paperairplane.mit.edu/16.423J/Space/SBE/muscle/muscle_bckgrnd_ug.html))

[0016] Despite all such available countermeasures, a recent NASA study showed that astronauts living aboard the International Space Station lost an average of 2.5 percent of bone mass in their hipbone, loss in outer bone at a rate of 1.6 to 1.7 percent per month and vertebrae bone mass loss at a rate of 0.8 to 0.9 percent a month. The NASA study also said that over the period of four to six month stays in space, the astronauts could lose 8.8 to 16.2 percent of their bone mass.

[0017] This presents a serious health risk to astronauts—even more so to those sent on voyages farther into the solar system such as to Mars, where the voyage might take two to three years. Moreover, upon reaching such distant destinations, the astronauts would have to be fit and healthy enough to meet the challenges of living and doing productive work there. It is therefore a necessity to counterbalance the negative physiological affects on astronauts’ muscular and skeletal systems due to zero or microgravity conditions.

BRIEF SUMMARY OF THE INVENTION

[0018] Accordingly, it is an object of the present invention to provide a system and apparatus that acts as an effective countermeasure against the loss of bone density and muscle atrophy of astronauts in zero gravity conditions.

[0019] It is another object of the present invention to reduce the time spent by astronauts on counterbalance measures, while producing similar or better results.

[0020] It is yet another object of the present invention to provide a system and apparatus that may be used by astronauts during their regular routine.

[0021] It is still yet another object of the present invention to provide a system and apparatus that may be used during the astronaut’s sleeping or resting period to counterbalance the loss of bone density and muscle atrophy of astronauts in zero gravity conditions.

[0022] It is still yet another object of the present invention to provide a system and apparatus that may be used to simulate later stages of long distance running and improve endurance and performance.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[0023] FIG. 1 is a diagram of an embodiment illustrating a system for counterbalancing the loss of bone density and muscle atrophy of astronauts in zero gravity conditions in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0024] FIG. 1 is a sketch of the illustrative embodiment of the present invention. The embodiment consists of a space

suit 100 that covers the upper torso of the astronaut—from the top of his head to a little below the waist. It is a skintight suit made up of elastic, polymeric material and consists of elastic straps 110 around the waist and the wrists; buckles 120 that go on these elastic straps and magnets 130 that go through and are held in place by these buckles. The space suit may also consist of a Velcro like internal strap 140 that mates with another strap worn on an inner layer or on the body of the astronaut.

[0025] The space suit 100 would be by worn by an astronaut while walking or exercising in an upright position on a treadmill with magnetic floorboards or in an enclosed magnetic chamber. The magnetic chamber would have magnetic flooring that would attract the magnets 130 on the elastic straps 110. The space suit 100 would thus experience a net downward force because of the magnetic attraction between the magnets 130 and the flooring of the magnetic chamber. The space suit 100, by its unique design and structure, spreads the force onto the muscular and skeletal system of the astronaut by applying a load on the median plane of the human body. As the astronaut tries to retain his upright position by resisting the forces of attraction between the magnets 130 and the magnetic flooring of the chamber, the force would also work on the lower torso of the astronaut and this process would simulate the force felt by the skeletal and muscular systems of an astronaut while on Earth.

[0026] As mentioned above, the space suit 100 may be used when the astronaut works out on a treadmill. The treadmill in this case would have a magnetic board as its base, similar to the flooring of the magnetic chamber described above. In the prior art, astronauts have been using elastic chords to hold them down on the treadmill and offer resistance. However, these elastic chords in the prior art do nothing to offer any resistance on the neck and head of the astronaut as these chords pretty much begin from the shoulder on downwards, which leads to negligible or insufficient loading/resistance on the vertebrae of the astronaut—as the vertebrae extends up into the neck and the bottom of the skull.

[0027] The space suit 100 may be used in conjunction with an additional component, a magnetic sole insert that may be placed in the shoe of the astronaut (or alternatively, the sole of the shoe itself may be made of magnetic material). This magnetic sole would also be subjected to the force of attraction due to the magnetic flooring and would help the astronaut stand upright. In addition, the magnetic sole would also apply a tensile force on the calf and lower leg muscles when the astronaut tries to walk or run on a treadmill i.e. in the process of removing or lifting the feet off the ground the astronaut would have to expend energy to overcome the forces of attraction between the magnetic sole and the flooring. This tensile force offers an additional component of resistance on the lower torso of the astronaut.

[0028] By choosing appropriate magnets 130 and appropriate magnetic flooring material, the strength of the magnetic force acting between the magnets/magnetic sole and the magnetic flooring may be adjusted to suit the desired load/resistance on the muscular and skeletal systems of the astronaut. The force may be increased to subject the astronaut to higher stresses than normal to help build up the muscular and skeletal strength and bone density in a shorter duration of time, thereby freeing up the astronaut’s time for other critical activities.

[0029] In another embodiment of the present invention, the system would have applications on Earth for long distance/endurance training and performance measurement purposes. For instance, consider a marathon runner. Typically, when the runner starts off, the amount of time that the feet of the runner touch the ground (time of contact) would be minimal. However, as the race progresses and the runner gets tired, the time of contact between the runner's feet and the ground increases progressively. By using the current system without the space suit i.e. only with magnetic flooring on a treadmill or a running track and with magnetic sole inserts or magnetic shoe soles, the runner's feet would be subject to the force of attraction between the sole and the track/treadmill thereby increasing the time of contact between the runner's feet and the ground (treadmill/track). This would help the runner in simulating the behavior of the feet during the later stages of a marathon without actually running the entire preceding stages. Moreover, the tensile force that acts on the runner's calf and other lower leg muscles also help build up additional strength in the same—in a high-fidelity (real life/actual usage) setting.

[0030] Changes and modifications may be made to the above scenarios without departing from the scope of the invention. For instance, a magnetic material like iron, which is attracted by a magnet, may replace the magnetic flooring in the magnetic chamber. In addition, an electromagnetic field may be used to produce the force of attraction on the magnets, magnetic sole etc. instead of the static magnetic field produced by the use of a magnetic flooring and magnets. Straps with magnets tied to the ankles may be used instead of magnetic soles inserts or magnetic soles. Further, the ceiling of the magnetic chamber may also be magnetically charged such that it repels a magnet placed on the head of the astronaut, thereby adding to the downward force that the astronaut feels. In a further deviation, the entry to the magnetic chamber may be controlled so that the astronaut feels a gradual increase in the magnetic force as he walks into the chamber instead of an abrupt change (and a sudden weight on his muscular and skeletal systems). The magnetic chamber may be designed so that the effects of the magnetic forces are felt internally only and not affect other systems outside the chamber.

[0031] In the foregoing specification, the invention has been described with reference to an illustrative embodiment thereof. However, it will be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense. Therefore, it is the object of the appended claims to cover all such modifications and changes as come within the true spirit and scope of the invention.

What is claimed is:

1. A system that uses a magnetic or electromagnetic field to apply a load on the muscular and skeletal system of the human body, the said system comprising of at least one magnetic or electromagnetic surface on which the human subject may stand on and a suit for the human subject consisting of at least one magnetic substance that would be subjected to the magnetic or electromagnetic field.

2. A system of claim 1, where the magnetic or electromagnetic surface on which the human subject may stand on is the floorboard of a treadmill.

3. A system of claim 1, where the magnetic or electromagnetic surface on which the human subject may stand on is placed below the floorboard of a treadmill.

4. A system of claim 1, where the magnetic or electromagnetic components are placed below a non-magnetic or non-electromagnetic floor on which the human subject may stand on.

5. A system of claim 1, where the suit worn by the human subject consists or one or more magnets or magnetic elements or electromagnetic elements at the lower extremity of the suit.

6. A system of claim 1, where the suit worn by the human subject consists or one or more magnets or magnetic elements or electromagnetic elements at different horizontal planes of the suit.

7. A system of claim 1, where the sole of the footwear worn by the human subject consists of magnetic or electromagnetic components that would be influenced by the said magnetic or electromagnetic field.

8. A system of claim 1, where the sole of the footwear worn by the human subject has an internal ridge-like structure towards the plantar surface of the feet.

9. A system of claim 1, where a sole-insert is placed in the footwear of the human subject, the sole-insert consisting of magnetic or electromagnetic components that would be influenced by the said magnetic or electromagnetic field.

10. A system of claim 1, where a sole-insert is placed in the footwear of the human subject, the sole-insert consisting of a ridge like structure towards the plantar surface of the feet.

11. A system of claim 1, where bands of magnetic or electromagnetic material are worn by the human subject on the calf-ankle region.

12. A system of claim 1, where the socks of the human subject are made of magnetic or electromagnetic material.

13. A system of claim 1, where bands of magnetic or electromagnetic material are worn by the human subject on the wrist region.

14. A system of claim 1, where the gloves of the human subject are made of magnetic or electromagnetic material.

15. A system of claim 1, where the electromagnetic force fields are generated from the floorboard or the region below the surface that the human subject stands on.

16. A system of claim 1, where the strength of the magnetic or electromagnetic fields may be dynamically changed.

17. A system of claim 1, where a magnetic and electromagnetic field exists on the path leading to the actual system.

18. A system of claim 17 where the magnetic or electromagnetic field on the pathway increases from the outer extreme to the entry point of the system described in claim 1.

19. A system of claim 1, such that the entire system is enclosed in a chamber that may insulate or reduce the magnetic or electromagnetic fields from having an effect outside the chamber.

20. A system of claim 1, where a magnetic or electromagnetic force may also be applied from the ceiling or the region above the head of the human subject.