REGENT

AN AXIAL LOADING SUIT TO ADDRESS MUSCLE UNLOADING AND MUSCLE DISUSE

Quick info

Developed by: The Institute of Biomedical Problems (IBMP) and Center for Aerospace Medicine and Technology

Headquarters: Russia

Year of Release: 1994

Awards: Gold medal and Diploma of the 55th World Salon of innovations, scientific research and new technologies "Brussels, Eureka 2006"; Gold medal and Diploma of the exhibition "High Technologies of the XXI century"; Gold medal and Diploma of the International Invention Fair "SIIF - 2006"

Product type: Wearable suit; Physical Rehabilitation

Primary application: Neurological and mobility impairments

Website

What does Regent do?

The Regent suit is an axial loading suit, meaning that it creates a set amount of tension which the body's muscles can work against, thereby exercising them. The concept is similar to stretching a rubber band; as fingers stretch a rubber band, the tension from the rubber band places more of a load on the muscles in the fingers which are stretching it. Similarly, a series of bands on the Regent suit are placed to target certain muscles, and as the individual moves while wearing the suit, the tension generated by the bands exercises the relevant muscles.

Exercising these muscles physically strengthens the muscles, but more importantly to its application stimulates motor centres in the brain. Stimulating these centres while performing movements correctly reorganise the connections in the brain, creating a new habit of moving correctly.

The suit itself is made up of a separate jacket and shorts combination, as well as optional shin and knee bands to load those muscles. The suit's system of bands and pulleys is located on the outside of the suit so that clinicians can easily adjust the level of tension to meet their patient's needs. The system also allows clinicians to adjust the load on different muscle groups to different levels. If, for example, a patient needs to strengthen use hamstrings can be separately increased.

The benefits of the Regent suit are plentiful. According to the IBMP website, the suit can "increase the resistive load when performing movements; correct gait and posture disorders; limit the hypermobility of the articular-ligamentous apparatus; perform muscle stretching, contributing to an increase in range of motion, as well as to prevent a possible sharp increase in muscle tone in response to physical exercises due to a more even distribution of the load;

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>
> *- Elena Tomilovskaya,*
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> *Head of the Department of Sensory-Motor Physiology and Countermeasures, IBMP*

increase the intensity of proprioceptive afferentation; positively influence the motivation of patients; improve motor function, speech, emotional status."

How does Regent work?

The Regent suit uses a dynamic proprioceptive correction method to achieve the effects listed above. This means that, to obtain results, patients must exercise while wearing the suit and thereby affect resistance against their muscles (dynamic) and that the suit builds connections in the brain which assist in kinaesthesia, or the patient's ability to sense how they are moving (proprioceptive).

The suit's dynamic nature is necessary because muscles are only activated when there is active resistance to their movement. If the muscle is not in movement, there will therefore be no load placed on it, and the suit will have no effect. Clinicians can prescribe a set of exercises based both on the patient's ability level and on which particular muscles require strengthening.

The suit's proprioceptive nature leverages the human brains neuroplasticity, or ability to make new connections between synapses. Within the motor centre of the brain, located in the cerebral cortex, connections between neurons called synapses convey information, such as how to move a certain muscle. Due to neuroplasticity, synapses which are used often become stronger, whereas synapses which are used less often become weaker or even die. As an individual exercises while wearing the Regent suit, the synapses which lead to correct movement are strengthened and eventually become the default, such that the brain automatically uses that synapse and performs the movement in the correct way. Meanwhile, the synapses which programme incorrect movement go from being the default to dying as they are replaced. Thus, after time, the patient's muscles begin to respond to the patient's prompts in a more correct manner.

Because of the suit's configuration, it also encourages its user to stand with a correct posture, building a habit even external to the tension system within the suit.

> *"The main goal of the suit is to create muscle loading, which is in deficit in individuals with certain diseases and disabilities."*

Who can Regent help?

The Regent suit is intended for adults and children with a range of neurological conditions, including cerebral palsy, injuries to the central nervous system, and other conditions arising from hemiparesis, tetraparesis, or atactic disorders. After repetitive exercise while wearing this suit, individuals with these conditions will be able to correct any movement disorders through changes to the motor centre of their brain.

The Regent suit was adapted from the Penguin suit, a Russian invention which was used by cosmonauts to prevent muscular atrophy. Because cosmonauts work under microgravity, their body no longer needs to support their weight as they move about. Day-to-day, cosmonauts therefore do not exercise their muscles as much as they would on Earth. Over time, this can lead to a loss in bone density as well as muscle atrophy from disuse. By placing an artificial strain on astronauts' muscles, the Penguin suit prevents this atrophy. The Penguin suit is very similar to the Regent suit, except that it iss customized for each cosmonaut and keep its system of bands and pulleys inside the suit, as there is no need for adjustment by another individual.

While the Regent suit is currently intended for individuals with neurological disorders, a similar suit could be used with the intention of strengthening muscles for a variety of purposes, including correcting weakened muscles after surgeries, exercising after injury, or increasing athletic performance.

How is Regent being implemented?

The Regent suit is currently in use at 43 different medical centres, most of which are in Russia and has passed clinical trials in Russia and other nations. Patients who wish to use the Regent suit should contact one of the institutions which uses it in their physical rehabilitation programs.

An Interview with Elena Tomilovskaya, Head of the Department of Sensory-Motor Physiology and Countermeasures, IBMP

What was the motivation behind creating the Regent suit? What inspired you?

The Regent suit evolved from the space prototype of the suit. In the early 1970s, when we started manned space flights, it turned out that space flights which are longer than 17 days posed a great risk for human health. That's why we started to develop the countermeasure program for space flights. First, we developed a system of physical training, which included a treadmill running exercises, resistive exercises, and veloergometry. We also developed a number of passive counter-measurements, which can be used during the day without requiring the full attention of the cosmonauts, so they can use it during their operator activities. Passive countermeasure means certainly cannot be used instead of physical training, but they can be a very good addition to it. To this end, we began working on axial weight loading. Initially, we made an axial loading suit which was called the Penguin suit, which has special rubber bands inside. The principle behind it is that we can set it up to load different muscles and muscle groups of the human body, such as the shin muscles or the hips or the abdominal muscles and so on.

This suit can provide axial loading from the neck to the feet and can be set up asymmetrically. For example, we can load the right leg more than the left one or load two of the back muscles, and so on. This suit was tested in different ground-based models like bedrest and Dry Immersion, and it was shown that it really can create the loading which is almost absent on board in weightlessness. We started to use this suit onboard and it gave us very good results in muscle loading and in predicting height increase. Height increase is also a big problem for the cosmonauts; the length of their body increases, and it is not good for their health, because in the G-transitions, it causes a very high risk of herniation of intervertebral discs. To limit this, we need to load muscles because they are unloaded in weightlessness.

> *"Muscle unloading and muscle disuse is not just a space problem, but also an Earth problem."*

However, muscle unloading and muscle disuse is not just a space problem, but also an Earth problem. This is not only for healthy people who are in hypodynamia conditions, but also for patients who have different nosology like cerebral palsy or who are recovering from a stroke. In many diseases, we also have the problem of muscle disuse, and we need to load the muscle system to create the correct postural picture to help the brain and to help the central nervous system control muscles and keep them in a nice state. Thus, we can actually use this suit in clinical applications.

That was not the idea of our department. Our department was headed at that time by academician Inessa Kozlovskaya, a very famous leader in gravitational physiology and countermeasures. One day, another professor Ksenia Semenova who worked with children with cerebral palsy, she came to Dr. Kozlovskaya and said, "You have a very nice suit and we suppose that something like this can also work very well for children with cerebral palsy." Inessa supported this idea very much, so they started to develop the clinical version of this suit called Adeli suit. When we tried this suit, it showed very good results for children with cerebral palsy because it turned out that if you create the correct postural synergies, if you load those muscles which should be loaded, then all the recovery processes go much better and faster.

They started to use it very intensively, so then the next step of this work was creating the next version of this suit. We named it the Regent suit, and it was tested in patients who had experienced strokes, patients with brain trauma, and patients with cerebral palsy. For all the people who need help with motor rehabilitation, it is very important to load the muscles in the right way, because during these pathologies, sometimes some of the muscles are spastic and some of them are rigid, which means they are not loaded in the correct scheme.

The Regent suit was created especially for clinics, unlike the Penguin suit. In space, with Penguin, you have all these rubber bands inside the suit and each suit is always custom-made for each cosmonaut. For

clinics, however, we cannot make individual suits, so we made several sizes of the suit for different heights and body weights. All the bands are also on the outside of the suit so the medical staff can control the loading of each element. Finally, the suit is also built to not be one piece, but to have different parts like a jacket and shorts, plus special additions for special parts such as the knees and shins. This allows you to control the loading of different areas of the body.

Have you faced any challenges in adapting between the space suit version and the clinical version?

The only challenge was to put all the elements outside of the suit so that they could be adjusted, which required a new design. It was the same principle, but another design because we needed to make it suitable and comfortable for medical staff so that they could work with it easily and individually set it up for the patients.

Was it difficult convincing stakeholders that there was a connection between space technologies and medical or accessibility technologies?

Collaboration with doctors with Professor Semenova (Dr. Ksenia Semenova) was very easy because it was her idea. She was very enthusiastic, and she was always involved in the testing of the suit and our various clinics. Certainly, though, when we offered this suit to other clinics, we had some discussions, and not all of them easily believed that the suit would help, because the suit seems to be very simple. It includes almost no electronic devices, just rubber and other elements which can be adjusted manually. When the sceptical clinics started to use it and made their own investigations, however, they saw that it really works.

Do you have any plans for future projects or additions to the Regent suit?

Yes, we have some plans. First of all, we want to add a system to monitor the loading, because right now the loading is mostly based on the experience of the medical staff who work with this. If instead we monitor the adjustable values for the loading of different segments of the suit, it would help very much, because then you can just remember the loading values for each segment from your previous session and can apply the same or change something just a little bit. This would be much easier than starting from zero every time. Another plan which we have is to combine this suit with electrical stimulation, because sometimes the muscle force is so low that just mechanical loading is not enough to rebuild and rehabilitate muscle, and in this case an electrical current can help to increase the muscle work.

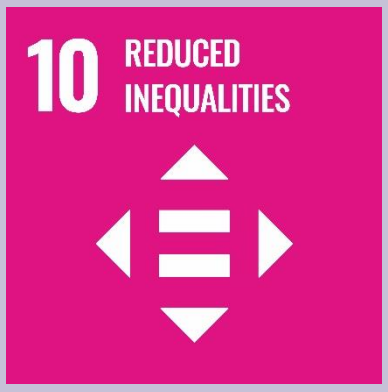
Could you describe something that you want our audience to remember about the Regent suit?

The main goal of the suit is to create muscle loading, which is in deficit in individuals with certain diseases and disabilities. Muscle loading is very important to create the correct postural synergy, and it can help very much with movement rehabilitation. This certainly doesn't mean that you just wear this suit and do nothing. This will not help you. You must do some gymnastics and special exercises while wearing the suit. Using this suit, though, can have incredible results. One example which was really impressive was that when children with cerebral palsy started to use this suit, we noticed that many of the children also improved their speech very much. It was strange, but if you take into account that the speech centres in in your brain are very close to the motor centres, you can understand that if you involve neuroplasticity of the motor centres, you will also initiate some neuroplasticity processes in speech centres. That's why these children also improved their speech while using this suit.

Is there anything you didn't have a chance to say or any parting thoughts you want to leave the audience with?

This suit is not designed for healthy people. However, you can use a version of it if you want to just increase your muscle loading when exercising. Mostly, though, this is for neurological patients who can move by themselves but do not do so correctly.

All photo credit: IMBP



ABOUT

This article is part of the "From Space to Earth: innovations enabling accessibility on Earth" project under the United Nations Office for Outer Space Affairs Space for Persons with Disabilities initiative. This project aims to raise awareness of the benefits of space technologies, spinoffs and related innovations in addressing challenges of disability, and to foster international and interdisciplinary collaborations on technological solutions to advance accessibility and empower persons with disabilities. This project contributes to the implementation of SDG 10: Reduced inequalities.

United Nations Office for Outer Space Affairs
Space for Persons with Disabilities
October 2023