Wearable muscle suit makes heavy lifting a cinch

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A lightweight exoskeleton will allow the elderly to move around more easily. New Scientist heads to a Japanese laboratory to try it on for size

Lift 40 kilograms? No problem *(Image: Robert Gilhooly)*

I'M IN a lab in downtown Tokyo full of grinning engineering students, who are peering past PC monitors and half-completed gadgets to watch me try and lift 40 kilograms of rice. No mean feat, but luckily I am about to be given a power boost.

I shuffle between some boxes and squat down as instructed by research student Hideyuki Umehara, aware of the clutter around me as I fight for floor space with the lower half of a mannequin, an electric wheelchair and an eerily realistic robotic head. Umehara places the bag of rice onto my outstretched arms. Then he presses a switch on the rucksack-like jacket I'm wearing, my hips are propelled forward and gradually my legs straighten until I'm completely upright.

It takes a second to register, but the 40 kg of rice I just picked up like a human forklift truck suddenly seem as light as a feather. Thanks to the "muscle suit" Umehara slipped onto my back prior to the exercise, I feel completely empowered. Fixed at the hips and shoulders by a padded waistband and straps, and extending part-way down the side of my legs, the exoskeleton has an A-shaped aluminium frame and sleeves that rotate freely at elbow and shoulder joints.

It weighs 9.2 kg, but the burst of air that Umehara injected into four artificial muscles attached on the back of the frame make both jacket and rice feel virtually weightless.

The muscle suit is one of a series of cybernetic exoskeletons developed by Hiroshi Kobayashi's team at the Tokyo University of Science in Japan. Scheduled for commercial release early next year, the wearable robot takes two forms: one augmenting the arms and back that is aimed at areas of commerce where heavy lifting is required. The other, a lighter, 5 kg version, will target the nursing industry to assist in lifting people in and out of bed, for example.

Kobayashi's muscle suit is the latest in a long line of exoskeletons dating back to General Electric's 1965 "man amplifier", the Hardiman. In the intervening years there have been a number of attempts to build devices that augment performance for soldiers, or to help disabled people. Some successful creations, such as the HULC by Ekso Bionics and Raytheon's XOS2, are still in development for the military.

Yet many exoskeleton projects hit problems early on that delayed or prevented commercial release. Most relate to the inability to generate sufficient power to safely drive the multiple motors required to mobilise the often-hefty suits.

Kobayashi believes his suit will be different. It doesn't have heavy electric actuators and hydraulics, but instead comes with PAMs - pneumatic artificial muscles. These lightweight, mesh-encased rubber bladders are designed to contract when pressurised air is pumped in. The PAMs give up to 30 kg of instant support or more, depending on how far the weight is away from the body. "The power-to-weight ratio is 400 times greater than motor-driven suits," says Kobayashi, who adds that unlike motors, PAMs are unaffected by water and dirt. A regulator controls the compressed air output based on a signal given by a microprocessor, which in turn communicates with an acceleration sensor in the frame that detects and responds to movement.

As well as its high power-to-weight ratio, the muscle suit's huge advantage, Kobayashi says, are its simple controls, which are largely preprogrammed to mimic natural human movements. Walking or lifting are triggered via the jacket's sensor, which responds to both simple voice commands, such as "start or "stop", and the body's acceleration. If the wearer is standing upright or moving more slowly than the preset acceleration threshold then the device will not move. A simple dial can control the suit's speed. The exoskeleton will be available to rent from ¥15,000 (£115) per month, although Japan's health insurance will cover 90 per cent of the charge in many cases.

"Years ago I was attracted by cool-looking robots, but basically they were of little use to society," Kobayashi said from his office, which is decorated with achievement awards and houses the prototype for his best-known creation, Saya the humanoid robot teacher. "I think our muscle suit is the only practically usable tool worldwide."

In Japan there has been a surge in R&D into exoskeletons, largely because of the country's rapidly ageing population: more than 30 per cent may be over 65 by 2025. In a recent science and technology white paper the government emphasised the need for robotic devices in a society where increasingly "the elderly will be caring for the elderly".

Later that day, I get the chance to try out the simpler version of the suit, which has no metal sleeves to support the arm. It is noticeably lighter, though the final product, says Umehara, will be lighter still, weighing around 4 kg. "I always thought this was part of fiction," he says, "but now, it's just a step away."

Let the muscle suit take the strain

Exoskeletons won't just help you lift heavy stuff, you'll also be able to hold it for longer. Hiroshi Kobayashi's team at the Tokyo University of Science, Japan, is measuring muscle fatigue using near-infrared spectroscopy, to gauge the benefits of their "muscle suit". Results show that continuous muscle use without the exoskeleton produces an increase in oxygenated haemoglobin or "oxy" and a decrease in deoxygenated haemoglobin or "doxy", which indicates muscle fatigue. The difference between oxy and doxy when using the muscle suit was negligible, Kobayashi said. The team expect to present their work at the International Conference on Intelligent Robots and Systems to be held in Portugal, in October.