Eliminating strenuous pushing and pulling for ambulance workers

Introduction
First responders and emergency workers are expected to be on call seven days a week, 24 hours a day, ready to help immediately and quickly. Improved work conditions make it easier to do that, but lifting patients on stretchers in and out of ambulances can be very difficult. An investigation in 2007 by Knibbe & Knibbe concluded that “a fundamental review of the way stretchers are loaded into an ambulance, and the way stretchers are raised, is necessary. Given the seriousness of overloading, completely new concepts must be considered.”

One important factor is the increasing weight of the population. Obesity is becoming an epidemic. Weighing 150kg is common. Assisting someone of that size can be physically demanding, and emergency workers risk becoming patients themselves, due to heavy lifting and pushing.

Clark Nowak from Move-in B.V. in Nijmegen, the Netherlands, decided to take on this challenge. Working with companies in the Nijmegen area, he developed an ingenious guide system that allows a stretcher to be moved in and out of an ambulance with minimal pushing, pulling and lifting.

The system works, both in concept and in practice. But how can you determine how much force is necessary, both with and without the guiding system? How do you prove that the system really does make an emergency worker’s job easier, and by how much?

Testing the information
The evidence is derived from measurement data being created, collected and analysed. And through analysis, a conclusion can be made. For this exercise, Move-in contacted the college in Arnhem and Nijmegen. The physiotherapy department decided that this

Sliding the weighted stretcher in and out of the ambulance

would make for an interesting graduation project, with significant social impact. It includes measuring the load behaviour applied by ambulance workers and how the load is reduced with the Move-in system. Three physiotherapy students, Daniël Nijman, Mitch van Dijk and Jasper van Steenhoven, took this on as a graduation project. The first problem the students had to solve was: “How do we collect the correct information?” In other words, how, where and with what means do

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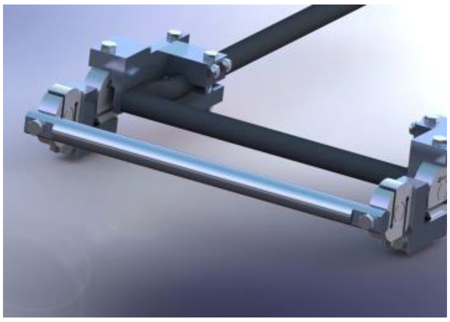
we measure push, pull and lift forces? That has more to do with instrumentation than with physiotherapy, so they looked for an expert. They found one in Ede, the Netherlands: PENKO Engineering B.V. The company has the right kind of sensors, instrumentation and computing systems to collect measurement data. And – perhaps most importantly – PENKO was enthusiastic about joining the project.

First, the position of the sensors was investigated. It was logical to mount them as close as possible to the handles, because that’s where the lifting, pulling and pushing takes place. Four pieces were selected – two to left and two to the right, of which two measured the push and pull forces on the X-axis and two measured the lifting forces on the Z-axis. (See picture 1.) The selected load cells use strain gages for measurements, determining the shear on the neutral axes of the load cell. That makes them relatively insensitive to side forces. The accuracy per load cell is 0.02kg, or 0.2N. They decided to check the four measuring signals independently, in order to detect possible undesirable side effects, such as crooked motion or the unilateral jamming of the stretcher in the guiding system. Extra attention was required for the load cells that measured the lifting forces. As in picture 1, the load was entered beside the axis of the load cells, which is affected by torque. Moreover, depending on the lifting height, an angular displacement was present. The load cell measured on its axis and the ambulance workers lifted vertically, so two indication errors took place. During the initial tests, the combined effect of both indication errors could be reproduced. In other words, the measurement results were not exact but mutually comparable. And that’s what this was all about: determining the lifting force with and without the Move-in system.



The Move-in's guiding system

Wheeling the stretcher in and out is a dynamic process. The load has to be collected continuously throughout the entire travel distance. That's why PENKO used a four-channel instrument to digitize the data for computer processing, with each sensor having its own input. Each input had 10,000d accuracy, a 24-bit internal resolution and a measuring speed of 1,600/s. Thanks to that combination, collecting measurements per 0.6ms with 0.2N accuracy was successful, while undesired side effects were eliminated by digital filters.

Testing

The tests were carried out using a Stryker M1 stretcher, with and without a Move-in. Before testing began, the four measuring systems were calibrated and adjusted independently, to meet international standards for weights. As noted earlier, the ability to reproduce the indication error of the load cells for lifting was proven. With adjustments, that effect was almost completely eliminated.

Testing took place at PENKO's factory, in order to eliminate changes in weather. Over the course of two half-days, a total of 19 volunteers – all active in emergency services – experimented with and without the Move-in system. Weights that meet international standards were used to simulate the weight of a patient. That meant that they could simulate patients in different weight classes, and determine the push, pull and lift forces of different volunteers, with and without the Move-in system. These sessions produced interesting results. Workers who trusted the system exerted less lift force for the same weight as their colleagues. And in general, the lift force lowered during testing. In their everyday work, the subjects are used to lifting. That's why adequate instruction and advanced training is essential to successful use of the system.

Analysis

This investigation showed that the Move-in system significantly reduces the lift forces while wheeling a stretcher in and out of an ambulance, by 0.7f and 150kg. While guiding a stretcher into the ambulance, the Move-in system reduces lift forces by approximately 50%. And when pulling it out,

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the results showed that the lift force reduction by the Move-in was dependent on the weight on the stretcher. For 150kg, that can be as high as 75%. The effect on the push force – necessary to slide the Move-in into an ambulance – is significantly higher, which is apparently caused by the rolling resistance of the Move-in's wheels. However, this differs only a few kilograms (1.22-2.22 kg). The pull forces didn't provide much information, as they are only significant at or above 75kg. The maximum difference between sliding in or out with and without the Move-in is 10 Newtons or 1kg. Lift forces when wheeling a stretcher in and out of an ambulance are the most impactful, so it's recommended to keep them to a minimum. The Move-in is a good solution. It can limit the effects of injuries, such as low back pain. Further tests to determine the exact impact on low back pain are needed. The way that emergency personnel move a stretcher into an ambulance has an effect on force. That's why it is recommended to have proper training before using the Move-in.

Conclusion

The Move-in system has proven its value. Those who participated in the project are satisfied that they were able to help improve work conditions for emergency workers.