Lucerne University of
Applied Sciences and Arts

HOCHSCHULE
LUZERN

Technik & Architektur
FH Zentralschweiz

MSE | MASTER OF SCIENCE IN ENGINEERING

Master of Science in Engineering
(HSLU) with Specialization in Medical
Engineering

Spinal Motion Analysis Using a Wearable Flexible Sensor

Problem definition

Back pain, and lumbar spine pain in particular, is one of the most common health complaints among astronauts during and after space flights. Studies show that up to 77% of astronauts develop back pain during their mission and that the risk of herniated discs is three to four times higher after space flights.
This is due to biomechanical adaptations to microgravity, including changes in the curvature of the spine, increased hydration and volume increase of the intervertebral discs and muscle atrophy of the deep back muscles. However, the exact mechanisms and load patterns of the spine are still poorly understood due to the lack of continuous measurements under everyday and space flight conditions.

Solution concept

The newly developed FlexTail sensor from MinkTec GmbH (Germany), which was developed in collaboration with scientific partners, is being investigated as an alternative solution (Figure 3). This is a flexible, portable sensor system that enables continuous recording of segmental spinal curvatures and movements under everyday conditions.
As part of this work, a validation study was carried out with six healthy test subjects. Standardized everyday movements such as standing, bending, sitting, walking and standing up were recorded. The aim was to check the measurement data of the FlexTail sensor with regard to plausibility, reproducibility and comparability with literature values and at the same time to identify practical and methodological challenges in the study design and sensor application.

Figure 3: FlexTail sensor (MinkTech Gmbh, n.d.)

Technology - state of the art

Laboratory-based and portable measuring systems are currently available for analyzing spinal movement.
The Vicon Motion Capture System (Figure 1) is considered the gold standard for three-dimensional motion analysis and delivers highly precise kinematic data. However, it is unsuitable for long-term or everyday measurements due to the complex setup, high costs and the fact that it is tied to a laboratory environment.
The Epionics Spine System is a portable sensor system for measuring lumbar spine movement in everyday life. It enables continuous recordings, but is sensitive to placement errors, dependent on liability and technically obsolete. In addition, the system is no longer in production (Figure 2).
Both systems are therefore only suitable to a limited extent for future applications in space flight.

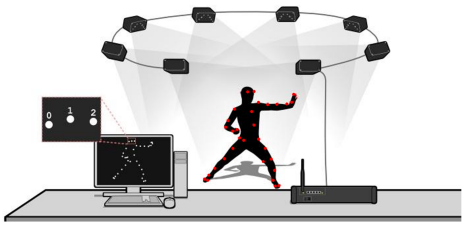

Figure 1: Motion Capture System (HTF Market Intelligence Consulting Private Limited, 2023)

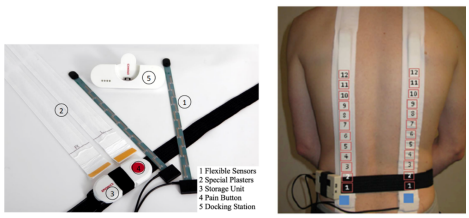

Figure 2: Epionics Spine System (Kwiatek, A., 2016)

Challenges of the study

Several practical challenges arose during the implementation of the study. In particular, sensor attachment proved to be problematic on oily or hairy skin and sometimes led to shifts in position.
In addition, there were occasional unintentional measurement interruptions due to the app's user interface. Fixing the electronic module of the sensor also posed a challenge, as fixing it too tightly could have a negative impact on the sensor position.
These aspects show that procedural and ergonomic optimizations are required in addition to technical validation.

Results

The flexion, extension and lordosis angles measured with the FlexTail sensor were predominantly within physiologically plausible ranges and showed consistent patterns between the test subjects.
Comparisons with literature values and reference systems (Vicon, Epionics Spine) showed good agreement, particularly during dynamic activities such as walking. Repeat measurements in one subject confirmed stable measurement repeatability without systematic outliers.
Overall, the results indicate that the FlexTail Sensor is fundamentally suitable for providing valid and reproducible information on spinal movement and represents a promising basis for future studies, particularly in the context of space travel.

Huda Munir
Advisor: Prof. Dr. Marcel Egli