

# Balance Effort, Cone of Economy, and Dynamic Compensatory Mechanisms in Common Degenerative Spinal Pathologies

Erin Shultz, BS; Thomas Kosztowski, MD; Damon Mar, PhD; Akwasi Boah, MD; Isador H. Lieberman, MD; Ram Haddas, PhD

Email: [eshultz@texasback.com](mailto:eshultz@texasback.com)

## INTRODUCTION

As a result of the many degenerative spinal pathologies, individuals may be at higher risk of falling, have higher muscle exertion to maintain balance, and experience overall poorer quality of life due to chronic pain when compared to individuals without a spinal disorder. Both static and dynamic balance assessments have been used previously in clinical settings such as physical therapy to evaluate patient balance, pertinent measures of which include the Romberg test and Dubousset's measurement of balance efficiency, the "Cone of Economy" (CoE) [1]. The Cone of Economy is both a visual and graphical representation of an individual's range of axial, coronal, and sagittal sway. The least range of sway can be seen at the patient's ankles, and motion is seen to increase in range all the way up to the greatest range measured, at the head. To create the Cone of Economy, sensors are placed superficially along multiple anatomical markers on the patient, and a number of movement, stability, and balance assessments may be performed. Through this recorded motion, 3D kinematic data is captured and is coded to quantify balance efficiency via range of sway, balance effort, and compensatory assessments. In general, those with spinal disorders present with decreased postural control, increased sway, and decreased ability to adapt to changes in balance when compared to healthy controls [2].

## METHODS

Subjects included three-hundred and forty individuals with one of six degenerative spinal pathologies, including cervical spondylotic myelopathy (CSM), adult degenerative scoliosis (ADS), sacroiliac dysfunction (SIJD), degenerative lumbar spondylolisthesis (DLS), single-level lumbar degeneration (LD), and failed back syndrome (FBS), along with 40 healthy controls. Each individual was first given a functional balance test in which they were asked to balance for 60 seconds with the eyes closed, and again for 60 seconds with the eyes open. Measures of sway were recorded. Boundaries from the CoE were recorded via measuring the range of sway, or differences in minimum and maximum sway in each plane. A balance analysis was performed for recording dynamic compensatory mechanisms in these patients as well, and patients were categorized by these compensatory mechanisms. Joint movements assessed for dynamic compensations included those at the ankle, knee, hip, pelvis, and trunk. To test for significant differences between degenerative spinal pathologies cohorts and healthy individuals, multiple one-way ANOVAs were performed using SPSS statistical analysis software.

## RESULTS AND DISCUSSION

When compared to healthy controls, patients with degenerative spinal pathologies had significantly greater balance effort as well

as increased dimensions of the CoE and range of sway. Overall sway at the center of mass and head were found to be more than or nearly twice that of the healthy controls (22.24±5.89 cm, 44.52±11.17 cm) for patients with SIJD (53.31±38.04 cm, 92.78±77.39 cm) and FBS (48.75±38.95 cm, 82.19±53.84 cm), respectively. In addition, the patients with degenerative spinal pathologies had more compensatory mechanisms than healthy controls overall. Compensatory mechanisms were demonstrated through greater exertion at the trunk, hip, and knee joints. Greatest differences from the healthy control group in compensations for balance were recorded for patients with ADS. This increased motion generally presents as disadvantageous to patients given higher energy consumption by pelvic and lumbar musculature in efforts to maintain balance about the patient's center of mass.

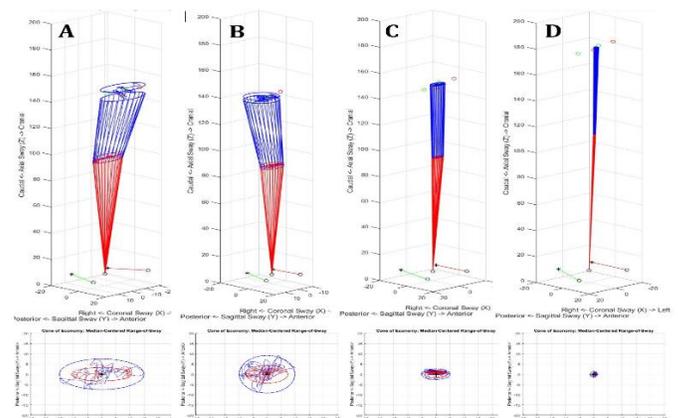


Figure 1: Representation of Cone of Economy and Range of Sway LDS (A), ADS (B), and FBS (C) & Healthy Control (D)

## SIGNIFICANCE

This research provides clinicians with a unique quantitative method of balance assessment for clinicians. Healthcare providers may use this method to assess the impact of a degenerative spinal pathology on patient balance or compare data prior to and after a surgical procedure is performed. The greatest range of sway differences were seen in the SIJD and FBS cohorts, while the greatest compensatory measurements were seen in those patients with ADS. Least compensatory differences were recorded for those patients in the DLS cohort.

## REFERENCES

- [1] Dubousset J. Three-dimensional analysis of the scoliotic deformity.
- [2] Haddas R, Lieberman IH. A method to quantify the "cone of economy".