INTRODUCTION: In man the diurnal cycle of erect and supine posture produces large changes in compressive load acting on the intervertebral disc over a period of twenty-four hours. These changes in compressive load result in fluid flowing into and out of the disc. This inflow and outflow of fluid is considered important for disc nutrition since the disc is essentially an avascular structure, and nutrients (and waste products) must be transported by a combination of diffusion and fluid flow.

Hitherto, there have been a few studies carried out to measure the changes in disc morphology (volume, height, and area) and the fluid flow to and from the disc. However, in these previous studies measurements were made at no more than three different time points in the disc’s diurnal cycle; measurements were not made to see how long during the day it takes a disc to lose the fluid gained during the night.

We decided to carry out a study using Magnetic Resonance Imaging (MRI) to answer the question: How much fluid does the disc gain during the night, and how quickly does the disc lose fluid during the following day during normal activity? It is important to understand how long it takes the disc to lose the fluid gained during overnight bed rest. This gives some insight into the rate of fluid transport for disc nutrition, and the compressive creep that the disc experiences during the course of a normal day’s activity. In the experiments reported here we measured the disc volume, from its lowest level (at the end of the day) to its highest level (the morning after a night’s bed rest). We then tracked the volume during an 8-hour protocol consisting of alternating periods of walking (40 minutes) and scanning (for about 10 minutes).

MATERIALS AND METHODS: Subjects: Five normal subjects were recruited after Human Investigations Committee approval was obtained. Each was interviewed as to their suitability and compliance to carry out the Timing Protocol (see below). The subjects consisted of four women, aged 21, 23, 31, and 32 years (Subjects 1-4), and one man aged 21 years (Subject 5). Younger subjects were chosen on the grounds that they are more likely to have normal discs.

Timing Protocol for MRI scans: Each subject arrived at the MRI Center in the evening. Each subject had been instructed that, for a period of at least ten hours before arrival, he or she should stay active by walking and standing, with the time spent sitting to be less than 30 minutes in any one-hour period. After arrival the subject remained upright for 60 minutes. They were then placed in a 1.5T MRI scanner and the first MR data scan was taken. The subject then slept overnight at the MRI Center. In the morning, after at least eight hours sleep, and after at least 90 minutes following the last rest room use, the subject was transferred to the MR scanner and a second MR data scan (the morning scan) was obtained.

After the AM scan, the subject got up and began an eight-hour protocol that consisted of a 40-minute period of walking followed by an MR data scan which required the subject to lie in a horizontal position (for approximately 10 minutes), then another 40-minute period of walking and another MR scan, and so on. Over the eight hours a total of ten scans were obtained. The MRI data for each subject thus consisted of an evening scan, a morning scan, and ten walking scans.

MRI Scan Parameters: The MRI scans were obtained using the standard clinical circularly-polarized spine coil. The scan from which the volumes were obtained (see below) consisted of a spin echo sequence with the following parameters: 18 contiguous 4 mm-thick sagittal slices; 700 ms repetition time (TR); 15 ms echo time (TE); 200 mm field of view; 512x512 acquisition matrix; 2 excitations (NEX); 7 minute acquisition time. Presaturation bands were used to suppress artifacts from abdominal motion.

Calculation of Disc Volumes: Measurements of disc volume were made for the lumbar discs L1/L2, L2/L3, L3/L4, and L4/L5 for each of the five subjects. The volume determination is described in complete detail in a previous paper: [Malko et al. Spine 1999; 24:1015-1022]. Briefly, the volumes were calculated from the disc areas obtained from the continuous set of sagittal slices. These disc areas were obtained by tracing the disc boundary.