PRESSURES APPLIED TO ANATOMICAL LANDMARKS OF THE KNEE WHILE IN KNEELING POSTURES

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INTRODUCTION

According to the Mine Safety and Health Administration (MSHA) injury database, 227 knee injuries were reported in underground coal mining in 2007 [1]. Low-seam coal mines are those with extremely low working heights (≤42"). Gallagher et. al [2] found that the average cost per knee injury in low-seam coal operations was $13,121.29. Thus, it can be estimated that the financial burden of knee injuries was nearly three million dollars in 2007. Pressure applied to the knee while kneeling and crawling is likely a risk factor. Typically, mine workers utilize kneepads to better distribute the pressures at the knee; however, their ability to reduce the stresses at the knee is unknown. The objective of this study was to determine the pressure applied to the knee during static postures used in low-seam mining while not wearing kneepads and while wearing two kneepads commonly used in the industry (one articulated and one non-articulated).

METHODS

Ten subjects (7 male, 3 female) with an average age of 34±17 years (19 to 60 years) and an average weight and height of 683±98 N and 168.7±8.0 cm, respectively, participated. The subjects simulated postures utilized in low-seam mines: kneeling in full flexion; kneeling at 90° of knee flexion; and kneeling on one knee. These postures were simulated with working heights of 38" and 48" except for kneeling at 90°. This posture was performed only in 48", since it is nearly impossible for adults at 38". These postures were simulated for three kneepad states: no kneepads, non-articulated kneepads, and articulated kneepads. Testing order was randomized.

A custom-made capacitive pressure sensor[1] was used that was pre-shaped to the knee when it was at 90° of flexion. With the sensor affixed to the knee, a researcher palpated around the patella, patellar tendon (PT), and tibial tubercle (TT) identifying the sensing units associated with each structure. The sensor was zeroed in non-weight bearing conditions with the subject's knee in 90° of knee flexion (for kneeling on one knee and kneeling at 90° of knee flexion) or when they were in a squat (for kneeling in full flexion). This ensured that the pressure measurements taken while the subject was in the assigned posture we ere only a result of the pressure applied directly to the knee by the floor and not due to pressure being applied to the sensor by the knee itself.

The subject assumed each of the five different postures and data were collected for 10 seconds. During analysis, the PT and TT data we reccombined due to their small individual size (~2 in.^{2}). The ratio of the pressure applied to the patella and the combined PT and TT was then determined for each point in time and the average of these ratios was taken to obtain a mean pressure ratio. For the patella and combined PT and TT, the maximum pressure at each point in time was then calculated and the average of these values taken to obtain the mean of the maximum pressure on each structure.

[1] Included 196 individual sensing units; Pressure Profile Systems, CA TactArray

A priori orthogonal contrasts were developed. Contrasts for kneepad states included comparisons of no kneepad state to wearing kneepads and comparing the non-articulated to articulated kneepads. All contrasts were tested using a T statistic using an alpha = 0.05

RESULTS

The majority (>60%) of the pressure was on the combined PT and TT for all postures (Figure 1). No difference was detected between the no kneepad and kneepad states, but a difference was detected between the articulated and non-articulated states. The presence of kneepads significantly reduced the mean of the maximum pressure applied to the combined PT and TT (Figure 2). The mean maximum pressure on the patella was much lower and ranged from 1.3 ± 1.1 psi to 27.1± 17.2 psi between postures. The pressure on the patella was sometimes higher with kneepads compared to the no kneepad state.

DISCUSSION

The pressure applied to the patella and combined PT and TT was determined for postures associated with low-seam mining. The majority of the pressure was transmitted to the knee via the combined PT and TT. While the kneepads did decrease the maximum pressure experienced at the combined PT and TT, pressures of greater than 25 psi were still experienced. At this time, it is unknown how this external pressure affects the internal stabilizing structures of the knee. The kneepads performed similarly despite significant differences in their material make-up. Some new kneepad designs in the industry have focused on eliminating the pressure at the patella. These data suggest that future kneepad designs should focus on redistributing the pressure at the combined PT and TT to other areas such as the shin.

REFERENCES

1. Mine Safety and Health Administration, *Injury and Illness Database*. 2007.
2. Gallagher, S., S. Moore, and P. Dempsey, *An Analysis of Injury Claims in Low-Seam Coal Mines*. Journal of Safety Research (submitted), 2008.

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DISLCAIMER

The findings and conclusions in this study are those of the authors and do not represent the views of the National Institute for Occupational Safety and Health.

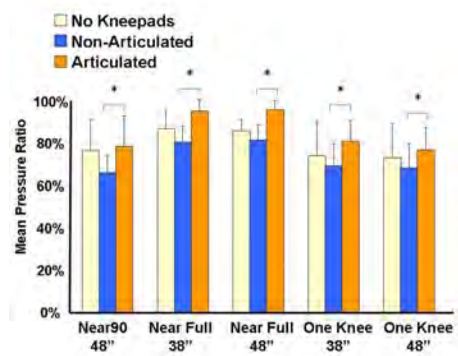

Figure 1. Mean pressure ratio at the combined PT and TT. *p<0.05

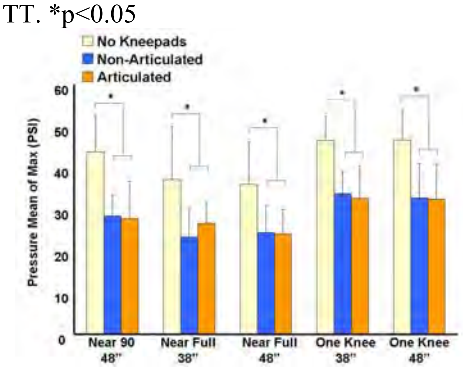

Figure 2. Mean of the maximum pressure at combined PT and TT. *p<0.05