Development of a Novel Kneepad for Mining

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Miners have to kneel, squat, and crawl to perform their work.

Kneeling/squatting is associated with knee injuries.

In 2007, 84 knee injuries (averaging $13,121 per injury) were reported to MSHA for seam heights of 30” – 54”.

With the aging mining population, the impact of knee injuries will be great.
Knee Injury Control Methods

- Increase working height of underground coal mines
- Change equipment to reduce the need to kneel or crawl
- Implement postural rotation strategies to minimize one’s exposure to kneeling hazards
- Personal protective equipment
• Which postures are used by miners to perform their work?
  – Predominantly kneeling near full flexion
• Do different job types use different postures?
  – Roof bolter operators and mechanics also kneel upright frequently
  – Continuous miner operators and foreman also crawl frequently
Biomechanics of Kneeling and Squatting

- Capacitive sensor technology measures pressure at right knee
- Motion Analysis System measures body position
- Electromyography measures muscle activity of knee flexors and extensors
- Force plates measure ground-reaction forces applied to right foot and knee
Results

- **Analysis of the effect of posture on joint loading**
  - Kneeling on one knee creates high shear forces on the knee
  - Kneeling near full flexion and squatting result in high knee moments
  - Sitting on one’s heels when kneeling in full flexion can reduce the loading on the knee

- **Analysis of the effect of posture on knee pressures**
  - Kneepads examined are effective at reducing peak pressures
  - High pressures (> 25 psi) still exist on bony landmarks (patella and patellar tendon/tibial tubercle regions)
  - Kneeling near full flexion results in reduced peak pressures
  - Kneeling on one knee and upright kneeling results in highest peak pressures
Kneepad Development

A need exists to improve the design of kneepads currently utilized in the low-seam coal mining industry.

The kneepad must:

1. reduce the stresses at the knee while in postures associated with low-seam mining;
2. be durable enough to withstand the mining environment; and
3. be well-accepted by the mine workers.
Path to Novel Kneepad

1. Initial Design Concept – Based on Biomechanical Data
2. Focus Groups – Miner Expectations
3. Design Kneepad Prototype
4. Evaluate Kneepad Prototype
5. Usability and Preliminary Durability Testing
6. Efficacy Testing
7. Full-Scale Field Evaluation
Miner Expectations of Kneepads

3 types of focus groups conducted:

• **User problems** – identified functional problems and undesirable characteristics associated with kneepads currently being utilized by underground coal miners

• **User design ideas** – determined characteristics of kneepads that are considered desirable to underground coal miners

• **User acceptance** – identified level of acceptance and document problems and undesirable characteristics of 1st generation prototype
Kneepad Design Evolution

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1st and 2nd Prototypes Evaluation

Height: 5'10.5"
Weight: 196 lbs.

Near 90°
- No Kneepad
- Blue
- 1st Prototype
- 2nd Prototype

Near Full
- 2nd Prototype with double padding

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Current State

- Prototype being redesigned with manufacturer
- Also researching other kneepad manufacturers
- Evaluating commercially available products for usage in mining
Commercially Available Kneepads

Kneeling upright with 5 different commercially available kneepads.
Usability and Durability Testing

- Does the kneepad shift during mining tasks?
- Does coal get trapped within the kneepad causing discomfort?
- Is the kneepad comfortable when worn for long periods of time?
- Are there any issues/problems cleaning the kneepad?
- Is the kneepad durable enough to withstand the mining environment for one month?
Kneepad Project Team

- Albert Cook – Technician
- Patrick Dempsey, PhD, CPE – Industrial Engineer, Ergonomist
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Collaborators

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• University of Pittsburgh
• Rockwood Casualty Insurance Company
• The Art Institute of Pittsburgh
• Coal Mines: Parkwood Resources, Rox Coal, TJS Mining, East Fairfield Coal Company, Rosebud Mining, Amfire Mining, Murray Energy
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