

INTRODUCTION

- Firefighting is associated with high rates of musculoskeletal (MSK) injury¹⁻⁵. Overexertion is the most common source of MSK injury among firefighters⁶.
- Evaluation of how tasks are performed can identify injury risks.
- Use of video-based software can help quantify firefighter tasks, but requires accuracy despite complex movement and equipment/clothing interfering with line of sight.

OBJECTIVES

- Primary: To describe hip and knee joint motion performance while lifting a high-rise pack (HRP) from floor to shoulder.
- Secondary: To determine
 - a) Relationship between hip joint displacement and isolated hip and knee joint angles
 - b) Extent to which height and weight contribute to hip joint displacement

METHOD

- Tasks were measured as part of a larger FIREWELL study⁸
- Participants: 48 active firefighters including 42 males and 6 females
- Data extraction: Dartfish[®] program using angle tracking and positional coordinates

RESULTS

Figure 1. DARTFISH user interface



Figure 2. Knee joint movement



- **Start:** Beginning of lift task.
- **Reach:** Firefighter’s hand touches the HRP
- **Stand:** Initiation of standing from kneeling
- **End:** End of the lifting task

Table 1. Lower extremity postures requirement

Left / Right	Ave.	Max.	Min.
Knee angle (°)	84 (L)	137 (L)	21 (L)
Arc of motion	96 (R)	153 (R)	42 (R)
Hip angle (°):	108 (L)	140 (L)	50 (L)
Arc of motion	76 (R)	163 (R)	29 (R)
Hip Vertical Displacement (m)	0.44 (L) 0.48 (R)	0.74 (L) 0.71 (R)	0.18 (L) 0.10 (R)
Height Normalized (%)	25 (L) 27 (R)	39 (L) 39 (R)	10 (L) 6 (R)

- **Arc of motion**
= Maximum angle -Minimum angle
- **Height normalized displacement (%)** =
$$\frac{\text{Max.} - \text{Min. displacement}}{\text{individual height}} \times 100$$
- **Regression Model**
Dependent variable:
Hip vertical displacement
$$Y=0.34*\text{knee}-0.07*\text{hip}+22.65 \quad R^2=0.66$$
$$Y=0.35*\text{knee}-0.08*\text{hip}-0.11*\text{weight}+33.13 \quad R^2=0.79$$

Dependent variable:
Normalized by height
$$Y=0.18*\text{knee}-0.04*\text{hip}+13.36 \quad R^2=0.62$$
$$Y=0.18*\text{knee}-0.04*\text{hip}-0.09*\text{weight}+21.98 \quad R^2=0.77$$

CONCLUSIONS

- Lifting a high rise pack involves a mean arc of motion of 84° for the left side and 96 ° for the right side at the knee .
- Displacement of the hip joint may be useful to estimate knee motion where angle measurements cannot be reliably obtained.
- The need to normalize displacement by height remains unclear.
- Future studies should focus on the reliability, potential for change, value of videos in task retraining and predictive value of different movement indicators.

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