Video-based Movement analysis for Occupationally Valid Evaluation (MOVE) to model firefighter lower extremity postures during a lift task.

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FIREWELL

KEY FINDINGS

- *This study identified that firefighters move through a flexion-extension arc of 84° for the left and 96° for the right knee, when lifting a high-rise pack.*
- *Our study proposes that the use of hip displacement may augment angular joint motion assessment of complex movements when performing video-based MOVE.*

Background

- Firefighting is a high-risk occupation that places substantial demands on the musculoskeletal system.[1-5] Movement analysis for occupationally valid evaluation (MOVE) requires reliable, accurate and contextually valid information for redesigning and training of high-risk tasks.

Objective

- The purpose of this study was to provide MOVE when describing hip and knee joint motion using video-motion analysis software to analyze firefighters lifting a high-rise pack (HRP) from floor to shoulder; and to determine the relationship between two approaches to quantifying motion: hip joint displacement (unadjusted and adjusted for height) and isolated hip and knee joint angles indicators.

Methods

- A sample of female firefighters (n = 6) and male firefighter participants (n = 42) were recruited from a single fire service in Hamilton, Ontario (women comprise 3% of this workforce).
- Data Collection: Video data was captured and recorded by two digital video cameras. Data extraction was performed using angle tracking and positional coordinates.

Results

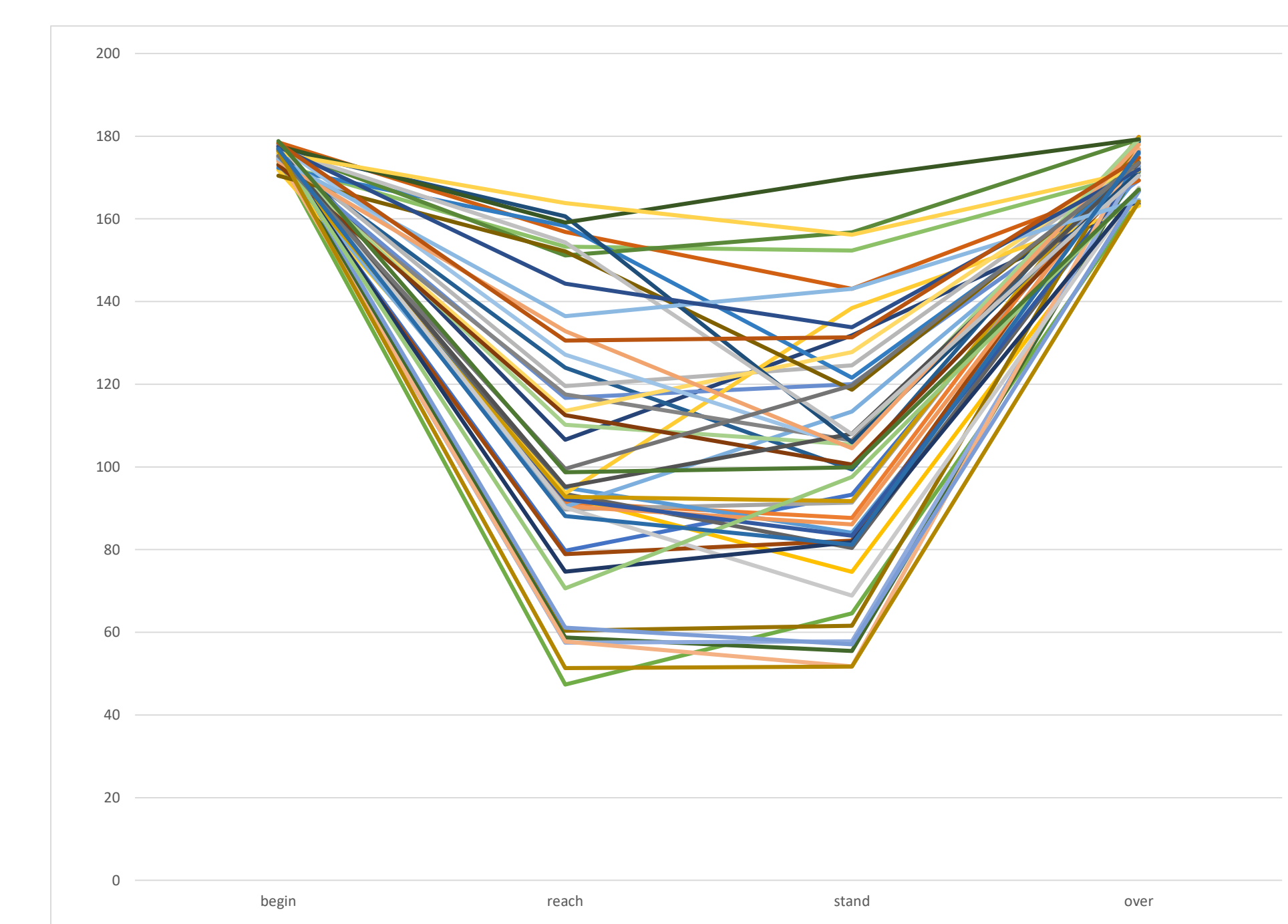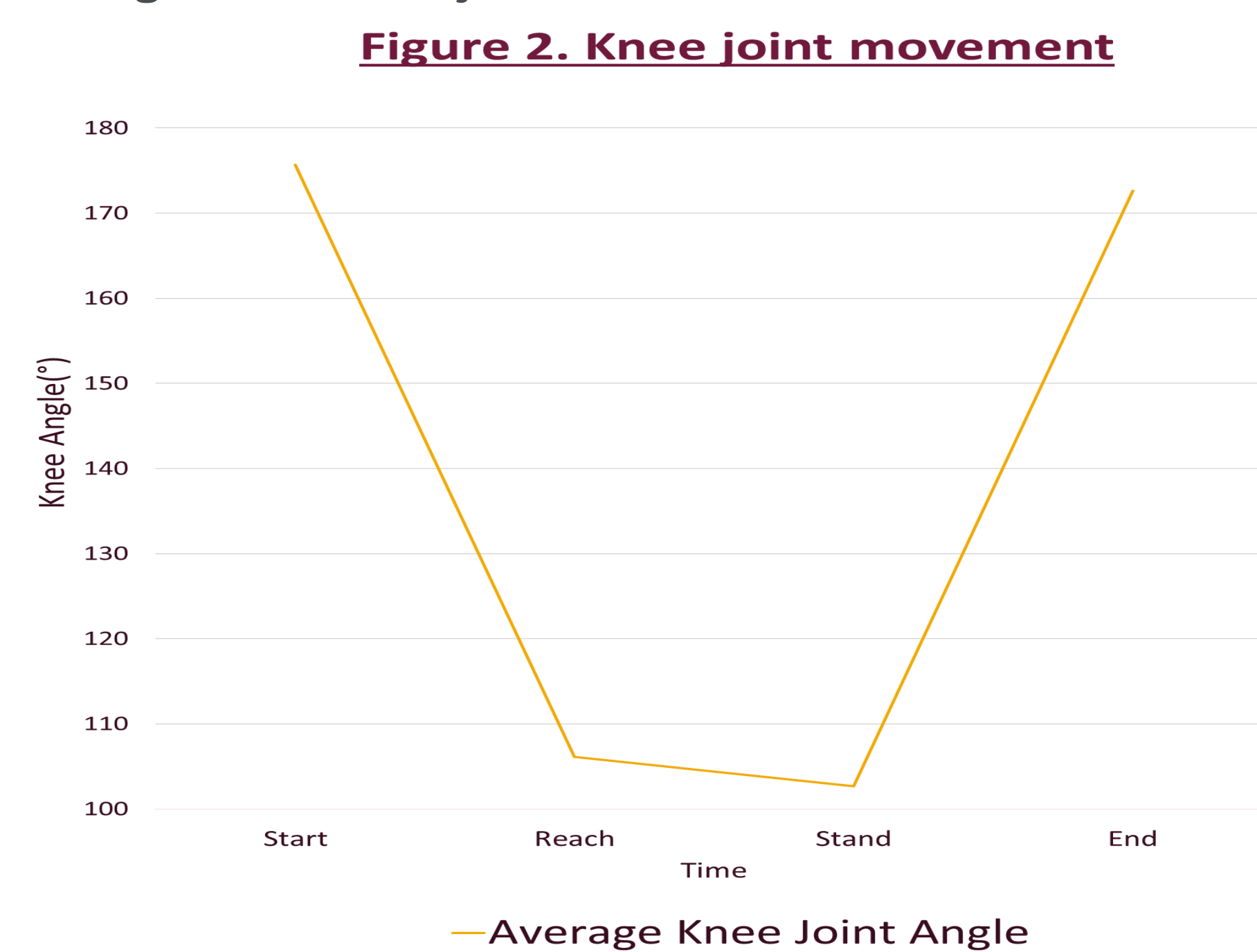- **Figure 1. Dartfish User Interface**

- **Figure 2. Knee joint movement**

Figure 2. Knee joint movement

— Average Knee Joint Angle

- **Table 1. Lower extremity postures**

Left / Right	Average	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	0.44 (L)	0.74 (L)	0.18 (L)
Displacement (m)	0.48 (R)	0.71 (R)	0.10 (R)
Height Normalized (%)	25 (L)	39 (L)	10 (L)
	27 (R)	39 (R)	6 (R)

- **Arc of motion** =
  Maximum angle − Minimum angle

- **Height-normalized displacement** =

$$\frac{\text{Max.} - \text{Min. displacement}}{\text{individual height}} \times 100$$

Regression Models for Hip Displacement

Dependent variable: Raw score
Y=0.34*knee-0.07*hip+22.65 R^2=0.66
Y=0.35*knee-0.08*hip-0.11*weight+33.13 R^2=0.79

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

Conclusions

- The study results suggest that lifting a high-rise pack involved mean knee arc of motion of 84˚(SD = 29˚) for the left side and 96˚ (SD = 33˚) for the right side.
- Angular movement moderately predicted displacement. Height-standardization did not affect the relationship between angular motion and hip displacement.

Discussion

- Vertical displacement measures may augment traditional angular arc-of-motion assessments when using a 2D measurement system for MOVE of firefighting tasks.
- Large arcs of motion are needed to compete a high-rise pack lift while wearing full personal protective equipment. Larger arcs of motion on the right side may reflect preferential kneeling on the dominant side.
- MOVE is challenging in complex occupational tasks, especially with protective equipment.
- The use of hip displacement as a surrogate measure to provide a composite indicator of hip/knee motion where angle measurements cannot be reliably obtained, requires further validation.

Reference

1. Park H, Trejo H, Miles M, Bauer A, Kim S, Stull J. Impact of firefighter gear on lower body range-of-motion. Int J Cloth Sci Technol. 2015;27(2):315–34.
2. Vieira ER, Kumar S. Working Postures: A Literature Review. J Occup Rehabil. 2004;14(2):143–59.
3. Kumar S. Theories of musculoskeletal injury causation. Ergonomics. 2001;44(1):17–47.
4. Karter MJ. NFPA's "Firefighter Injuries in the United States." 2014.
5. Karter MJ, Molis JL. U.S. firefighter injuries in 2010. NFPA Journal; 2010. p. 71–6.

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