A Case-Control Evaluation of Body Kinematic Differences Among Male and Female Firefighters Using Dartfish Video Analysis

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KEY FINDINGS

Finding #1: Female firefighters tend to engage in protective lifting biomechanics by using a more conservative approach than MFs through the use of their legs to lift in order to reduce spinal loading.

Finding #2: Qualitative findings suggest that female firefighters appear to be more variable in their movement strategies when compared with their male counterpart.

Background

- Female firefighters (FF) are at increased exposure to injury due to physiological differences, physical demands, and lack of suitable equipment[1].
- Female firefighter report a 33% higher rate of injury than male firefighters (MF)[2].
- Female firefighters differ from males in terms of muscle strength and endurance, and task performance outcome measures[3-6].

Objective

- Potential sex and gender differences suggesting differential injury risk has been identified, but a target study is yet to be conducted[2-7].
- Objective: to perform a detailed analysis in order to determine whether MF and FF performing firefighting tasks use similar body kinematic strategies.

Methods

- **Design**
  - Case control study: participants were first matched based on weight, followed by height. A match was achieved when a FF was within 2kg and 4inches of a MF (Table 1).
- **Participants**
  - Secondary analysis of active duty MF and FF performing the hose drag task.
- **Data Collection**
  - Dartfish video analysis software (Figure 1).
  - See Table 2 for kinematic variables extracted from Dartfish.
  - Qualitative observations of movement strategies.
- **Data Analysis**
  - Paired t-tests were conducted in order to determine any statistical difference between MFs and FFs.

Table 1: Demographics of male and female firefighters.

Match	Male (n=4)	Female (n=8)
1	Weight: 68kg Height: 173cm	Weight: 68kg Height: 173cm
2	Weight: 68kg Height: 173cm	Weight: 68kg Height: 175cm
3	Weight: 68kg Height: 173cm	Weight: 68kg Height: 168cm
4	Weight: 68kg Height: 173cm	Weight: 63kg Height: 163cm
5	Weight:73kg Height: 173cm	Weight: 73kg Height: 165cm
6	Weight: 73kg Height: 173cm	Weight: 75kg Height: 170cm
7	Weight: 78kg Height: 175cm	Weight: 78kg Height: 170cm
8	Weight: 90kg Height: 170cm	Weight: 90kg Height: 165cm

Results

Figure 1: Dartfish user interface.

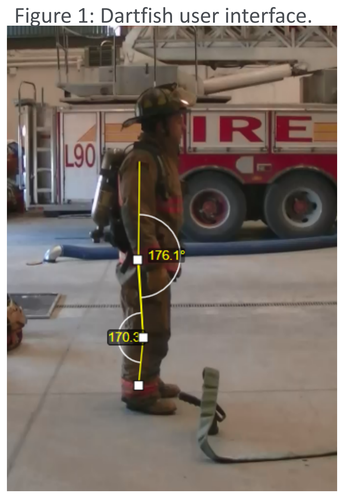


Table 2: Average male and female results and the appropriate p-values obtained from the paired t-test.

Variable Measured	Male Average	Female Average	p-value
Maximum knee angle (˚)	172.57	170.11	0.149
Minimum knee angle (˚)	135.73	105.1	0.017*
Knee ROM (˚)	36.85	64.4	0.012*
Maximum hip angle (˚)	176.48	173.56	0.215
Minimum hip angle (˚)	64.15	67.45	0.788
Hip ROM (˚)	112.33	106.11	0.986
Forward Torso Lean Angle (˚)	130.48	155	0.006*
Relative Vertical Hip Displacement	26.85	22.76	0.264
Stance width (m)	0.73	0.69	0.945

* p<0.05 = statistically significant difference.

Figure 2: Minimum knee angle sorted by match.

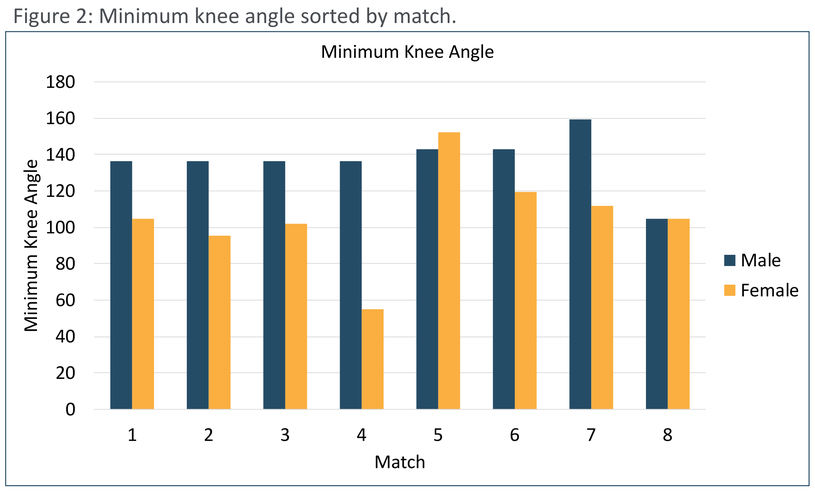


Figure 3: Knee ROM sorted by match.

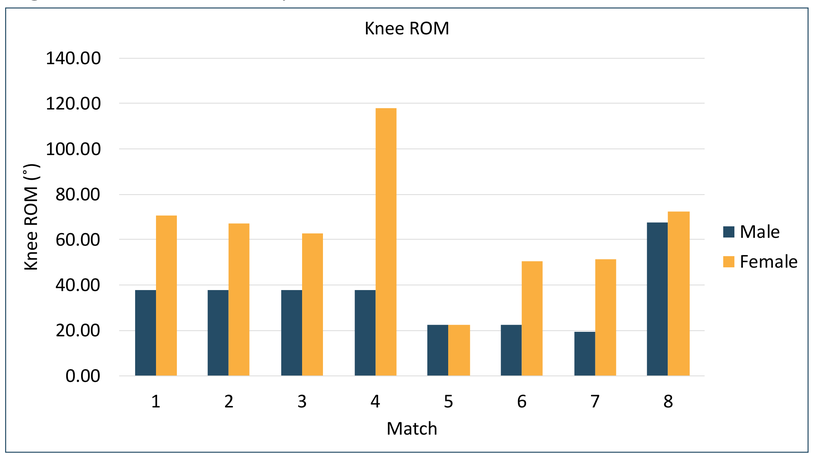
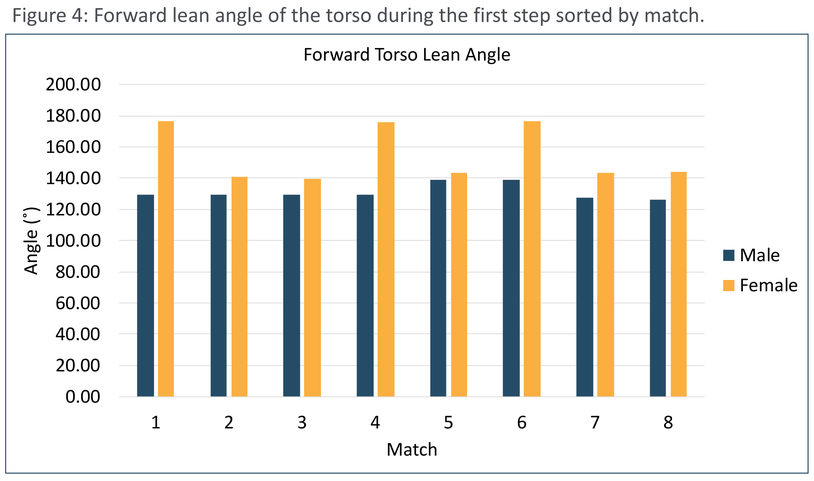


Figure 4: Forward lean angle of the torso during the first step sorted by match.



Conclusions

HOW DO FF AND MF COMPARE?

- FF have a greater knee ROM, smaller minimum knee angle, and greater forward trunk lean during their first stride.
- Qualitative findings:
  - All MFs stepped with their right foot first, while only 57% of FFs stepped with their right foot first (Figure 5).
  - All MFs placed hose over their shoulder, while only 62.5% of FFs placed the hose over their shoulder (Figure 6).

Figure 5: Foot used during first stride separated by sex.

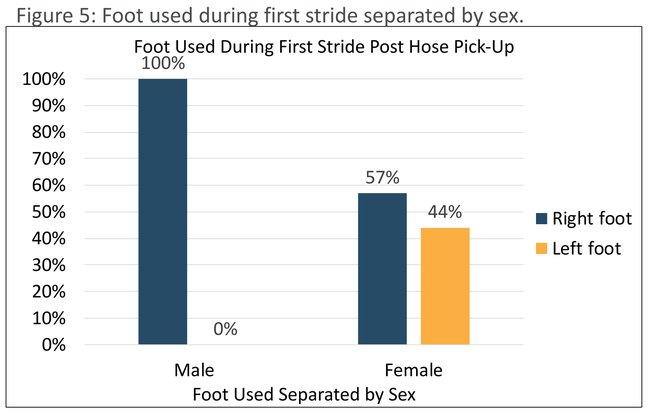
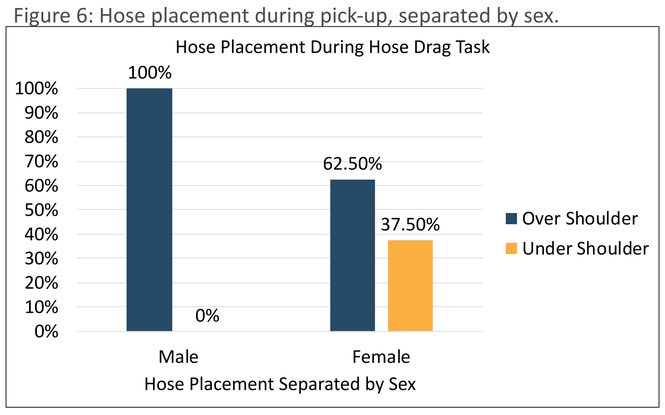


Figure 6: Hose placement during pick-up, separated by sex.



WHAT DO THESE FINDINGS MEAN?

- More knee flexion during hose lift and more forward lean upon first step in FFs suggests that MFs bend with their trunks rather than using their knees to lift and pull.
- FFs more variable in their movements than MFs when qualitatively observing hose placement and which foot was used during the first step. Although it is unknown whether the variation in which foot was used is a result of leg dominance, it would be interesting for future research to consider.

WHY MIGHT THIS BE?

- FFs tend to engage in protective lifting biomechanics by using a more conservative approach than MFs through the use of their legs to lift in order to reduce spinal loading.

Future Research

- Observing the effect of implementing ergonomic training among both MFs and FFs.
- Explore in more detail the variability that was qualitatively observed among MFs and FFs. Was the variation that was found in the foot used toward load stabilization among FFs a result of foot dominance?
- Explore a larger sample size.

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