Contemporary Modes of Conveyance: Research Highlights

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10 May 2016
Outline

- Statistics, background
- Studies of modes of conveyance
  - Stair descent devices
  - Cots
- Adapting to change
2014 Incidence rate for EMS and paramedics: **333 per 10,000 FTE**, all injuries and illnesses BLS

2014 Incidence rate for EMS and paramedics: **184 per 10,000 FTE**, musculoskeletal disorders (MSDs) BLS

The most common events were overexertion (12,146, 56%), falls (2,169, 10%), and transportation-related (1,940, 9%). Maguire & Smith, 2013

A total of 14,470 cases (67%) involved sprains or strains; back injury was reported in 9,290 of the cases (43%); and the patient was listed as the source of injury in 7,960 (37%) cases. Maguire & Smith, 2013

Number of jobs, EMTs & Paramedics: 241,200
Job Outlook, 2014-2024: +24%
BLS

2014 number of cases, all injuries and illnesses for EMS and paramedics: **7010 cases** BLS

2014 number of cases, MSDs for EMS and paramedics: **3880 cases** BLS

Contributing factors: stairs/steps in private residence; activity involving cot Furber et al., 1997
Modes of conveyance – there is a difference

- Evidence of reduced physical stress:
  - Less muscle activity = less force required → less muscle fatigue
  - Reduced ground reaction force = less weight supported by paramedic
  - Reduced perceived exertion

- Other important measures include:
  - Time to complete task
Where does it seem that people who need transport are located?
Why can’t all homes be single story homes?
Research Study  *(FEMA 2009-EMW-FP-01944)*

- **Objectives:** Evaluate different *stair descent devices* for evacuating individuals when stair descents are required.

- **Types of devices:** Carried, Track, Sled

- **Measure:**
  - Physical demands
  - Performance (evacuation speed)
  - Usability

- **Task factors:**
  - Staircase Width (0.91, 1.12, 1.32 m)
  - Urgency (Urgent, non-urgent)
Hand Carry Devices

Extended Handle SC

Basic SC

Manual Carry

Fabric Seat
Track-Type Devices

- Long Track (Garaventa)
- Rear Facing (Glider)
- 2-Wheeled (Evac+Chair)
- Narrow (AOK)
- Standard (Ferno EZ-Glide)
Sled-Type Devices

- Roll-up (Med Sled)
- Corrugated (Evacuslyde)
- Wheeled (Subway Sled)
- Inflatable (Hover Jack)
- Hardshell (Lifeslider)
- Fabric Mat (ResQmat)
Research methods

• Study participants: 12 experienced male firefighter-paramedics
• Patient: Rescue Randy (73 kg=160 lbs)
• Measurements:
  ✔️ Duration of evacuation
  ✔️ Electromyography: trunk, shoulder, arms
  ✔️ Heart Rate
    • Perceived exertion ratings
    • Spine motion
    • Usability information via post study interview
Findings
### Stair Descent Speed:

**Hand-Carried Devices: 1.12 m Staircase Width**

<table>
<thead>
<tr>
<th>Device</th>
<th>Speed (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Carry</td>
<td>0.3</td>
</tr>
<tr>
<td>Basic Stair Chair</td>
<td>0.3</td>
</tr>
<tr>
<td>Fabric Seat</td>
<td>0.3</td>
</tr>
<tr>
<td>Extended Handle</td>
<td>0.8</td>
</tr>
</tbody>
</table>


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Stair Descent Speed
Track-Type Devices: 1.12 & 1.32 m staircase widths

Stair Descent Speed:
Sled Devices: 1.12 and 1.32 m Staircase Widths

Slow, compared to track style and extended handle hand-carry device

\[ p \text{ values (Width <0.001 Devices <0.001 Device x width = 0.553)} \]
Heart Rate – Percent Max
Hand Carried Devices

Hand-Carried Stair Descent Device

<table>
<thead>
<tr>
<th>Device</th>
<th>% maximum heart rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual</td>
<td>54.4</td>
</tr>
<tr>
<td>Fabric</td>
<td>47.7</td>
</tr>
<tr>
<td>Basic</td>
<td>47.0</td>
</tr>
<tr>
<td>Extended Handle</td>
<td>35.8</td>
</tr>
</tbody>
</table>
Heart Rate – Percent Max
Track-type Devices

![Graph showing heart rate percentages for different devices: Rear Facing 50.9%, 2-Wheel 48.7%, Long Track 48.5%, Narrow 47.0%, Standard 43.5%]
Heart Rate – Percent Max
Sled Type Devices

SLED TYPE / EVACUATOR ROLL

% of Age adjusted Maximum Heart Rate

Wheeled (Leader)  Hard Shell (Follower)  Corrugated Follower  Roll-up Follower  Corrugated Leader  Roll-up Leader  Fabric Mat Leader  Inflatable Leader  Inflatable Follower  Fabric Mat Follower
Arm and Shoulder Muscle Activity:
Track Type Devices: Landing, 1.12 and 1.32m

2-W = 2-Wheel / Nar = Narrow / Std = Standard / RF = Rear-Facing / LT = Long-Track
Back (Erector Spinae) Muscle Activity:
Sled Type Devices:

![Graph showing muscle activity for different sled types and roles.](image-url)
Back (Latissimus Dorsi) Muscle Activity: Sled Type Devices: Landing
# Objective Measures - Analysis Summary

<table>
<thead>
<tr>
<th>Device</th>
<th>Positives</th>
<th>Negatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand-Carried</td>
<td>Less Expensive</td>
<td>Higher physical demands; Slower – Unless lead person can face forward</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Track-type</td>
<td>Reduced back muscle use; Faster</td>
<td>Latissimus use – on stairs, landings</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sled-type</td>
<td>Low muscle demands on stairs.</td>
<td>Transfer in/out; High demands on landing</td>
</tr>
</tbody>
</table>
Conclusions from Stair Descent Device Studies

• Track-type devices – several advantages:
  • Evacuation speed
  • Physical demands
  • Ingress / Egress for occupant

• If a hand-carried device is used, device width and handles should support lead person descending facing forward
Cot study I – manual cots

• Design characteristics investigated:
  • Leg folding mechanism
  • Handle design options

• Research methods:
  • 15 experienced EMTs & paramedics (4 F)
  • Lab-based study
  • Tasks: load, unload, raise
  • Weight: 23kg for F, 45 kg for M
  • Measurements: muscle activity, joint stress, subject ratings (RPE), task time
Cot study I

• Findings

Peak muscle activity during loading

Muscles: arm, shoulder, back
Cot study I

- Findings, cont.
Cot study I

• Findings, cont.
Cot study I

- Unloading: Interaction of subject height and handle design
Cot study II – powered cots

• Design characteristics investigated:
  • Leg folding mechanism

• Research methods:
  • 16 experienced male EMTs & paramedics
  • Lab-based study
  • Tasks: load, unload
  • Weight: 45, 68, 91 kg
  • Measurements: muscle activity, ground reaction force, subject ratings (RPE), task time
Cot study II

• Findings
Cot study II

• Findings, cont.

Vertical ground reaction forces, less participant’s body weight, represent external holding and peak vertical loads experienced.
Cot study II

• Findings, cont.

Perceived exertion

<table>
<thead>
<tr>
<th>Cot A</th>
<th>Cot B</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 kg</td>
<td>68 kg</td>
</tr>
<tr>
<td>91 kg</td>
<td></td>
</tr>
</tbody>
</table>

Loading

Rating of Perceived Exertion (CR-10 scale)

- a, a, b
- d, e, f
Cot study II

• Findings, cont.

• Perceived task time:
  “I think that the legs of this cot fold and unfold too slowly.”
  Cot A – somewhat disagree
  Cot B – somewhat agree - agree
Change
Factors that influence adoption in the early stages of implementation of safety-related changes

8 major themes in successful/unsuccessful implementation:

1. Implementation leadership
2. Effective training
3. Presence of mock-up
4. Active interaction with employee
5. Trialing and flexibility
6. Employee in the loop
7. Employee's perception
8. Reflection, understanding, internalization
Study of factors affecting paramedics’ adoption of a tri-fold slide board

Conclusion

- Engineering controls can reduce physical loads
- Intervention adoption is a process; requires input from users, time to learn, supportive environment, must fit application and constraints, ...
Research Collaborators

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- Students:
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  - Nicholas Schmidt
  - Christina Lee
Bibliography: EMS research publications


