Reducing manual handling injury risk through trolley design in an anatomy teaching laboratory

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CONTEXT

• The University of Melbourne teaches anatomy of the human body to medical, surgical and allied health students.

• Examination of the human body is undertaken in a large, busy teaching laboratory in the Faculty of Medicine, Dentistry & Health Science, Parkville.

• Technical staff, responsible for preparing laboratories for anatomy practical classes are reporting musculoskeletal discomfort associated with moving trolleys and other manual handling tasks.
CURRENT STATUS

• Technicians have submitted incident reports for musculoskeletal injuries to the lower back associated with manual handling activities.

• Laboratory manager has escalated this issue to relevant OHS personnel.

• The need for investigation into the current methods of manual handling related activities within this area has been identified.

• Pushing and pulling activities are a known occupational hazard.
• WorkSafe Victoria musculoskeletal injury data 2013-2014
METHODOLOGY/APPROACH

• A preliminary meeting with key stakeholders (technician, their manager and OHS personnel) was undertaken to establish the background and identify the hazardous manual handling activities/practices

• Assessment/analysis of the identified manual handling activities and practices

• Implementation of control measures

• Evaluation of control measures
BACKGROUND

*Past Practices pre-2006*

- Activities using 40-50 cadavers per year- proportionate to number of enrolled students.

- Cadavers remained on fixed/static tables during the year, with minimal movement of trolleys during the year.

- A pallet jack was used to move trolleys when necessary.

- 4 Technical staff were employed.
Current Practices:

- Activities using 120 - 140 cadavers per year-proportionate to number of enrolled students
- Demand for room usage and activities has increased substantially
- Cadavers housed on mobile trolleys
- Trolleys require regular rotations – up to 3 x a day, 3 x a week
- Three full time technical staff employed
- Increase in cadaver body weight reflecting a broader population trend
KEY ISSUES IDENTIFIED FOR ASSESSMENT/ANALYSIS:

1) Systems of work

2) Cadaver trolleys

3) Load characteristics

4) Other factors
1. Systems of work:

* Scheduling, time demands, frequency of moving cadaver trolleys*

- Substantial increase in cadaver numbers used over recent years
  - From 40 – 50 cadavers → 120 – 140 cadavers per year

- Laboratory is in high demand necessitating high frequency of moving cadaver trolleys → around 60 – 80 trolleys to move before each practical class- up to 3 x per day, 3 days per week

- There is limited time available between classes for setting up → 15 – 60 minutes only necessitating working quickly

- Three technical staff only employed to manage the high workload

- Trolleys do not lend themselves to being handled by two persons
2. Cadaver Trolley

2.1 Design of trolley

• Standard commercial stainless steel mortuary trolleys. Dimensions: 2070mm long x 620mm wide x 860mm high.

• Approximately 20kg unloaded.

• 4 swivel castors with foot operated brakes.

• Handles fitted to both ends.

• Cadavers are covered with a plastic, protective covering with elasticised edges.
2. Cadaver Trolley
Covers
2. Cadaver Trolley

2.2. Castors

- 4 x125 mm diametre swivel, lockable castors with flat tread profile rubber tyres

- Castor diameter affects trolley movement forces, maneuverability and handling. 125mm diametre castors not recommended for patient trolleys. 175-200mm diametre castors are more suitable.

- The castor configuration is suitable - enables manoeuvrability-forwards, backwards, sideways.

- Flat tyres have more surface area in contact with the floor-more resistance to overcome. Round profile tyres have less contact with the floor-so much easier to swivel
2. Cadaver Trolley

2.3 Handles

- Fixed 860mm high horizontal handles both ends external to trolley footprint
- 80mm circumference, 620mm length, adequate clearance to enable a power grip
- Covers restrict access to the handles so generally not used
- Trolleys are moved from the sides as well as the ends

- Trolley handle design dictates hand grip, force application and body posture. Recommended handle height is 70-80% of users shoulder height. Handles designed in this range impose least strain on the wrists and hands and lower compression force at L5-S1 (lower back).

- Optimal handle height for the 50th 5ile female is 910mm, males 960mm. A good compromise is 950mm. Current 860mm handle height is well below this.

- Horizontal handles- static height, inefficient, high stress wrist posture. Vertical handles accommodate a large range of user heights and enables a neutral wrist posture (hand shake position).

- Presence of cover dictates hand grip.
3. Load characteristics

• Embalming process adds approximately 30-40kg to cadaver weight

• Weight of loaded cadaver trolley- estimated between 100 – 150 kg

• Cadavers donated to medical science are becoming larger, heavier
4. Other relevant factors - environmental/individual

• Floor surface is vinyl, slip-resistant, well maintained.

• Technicians gender and anthropometric variation: both static- e.g. stature, hand size; and functional e.g. reach, strength capability.

• Technicians individual work methods.

• Technicians footwear – generally observed to be appropriate e.g. rubber soled, flat, supportive.
Trolley Assessment methods

• An analogue force gauge instrument applied directly to the trolley was used to measure push/pull forces
• 3 castor starting positions were tested
• Measures were taken from both the side and head end
• Each measure was repeated 3 times
• The test load (cadaver trolley) was ‘medium’ size/weight.
• The suggested maximum force is an estimate of the maximum force a worker should exert under the conditions selected
### PUSH/PULL FORCE MEASUREMENTS: CADAVER TROLLEY.

<table>
<thead>
<tr>
<th>ORIGINAL TROLLEY Location of force exertion</th>
<th>Starting position: Wheels perpendicular to direction of travel</th>
<th>Starting position: Wheels aligned with direction of travel</th>
<th>Starting position: Wheels 180 degrees to direction of travel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push/pull from side-force gauge applied to side of trolley slightly towards head end</td>
<td>Initial: 16kgf</td>
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<tr>
<td>Push/pull from end-force gauge applied to mid-point of horizontal handles at head end</td>
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## ACCEPTABLE PUSH PULL FORCES

<table>
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<tr>
<th>USER</th>
<th>INITIAL FORCE = MAXIMUM FORCE EXERTION (1-5 SEC. DURATION WITHOUT STRAIN)</th>
<th>ONGOING FORCE = SUSTAINED FORCE (LONG DURATION &amp; FREQ. INTERMITTENT USE)</th>
</tr>
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<tr>
<td>5 %ile. f (small female)</td>
<td>10 kgf</td>
<td>4 kgf</td>
</tr>
<tr>
<td>5 %ile. m (small male)</td>
<td>15kgf</td>
<td>6 kgf</td>
</tr>
<tr>
<td>95 %ile. f. (large female)</td>
<td>30kgf</td>
<td>11 kgf</td>
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<tr>
<td>95 %ile m (large male)</td>
<td>46 kgf</td>
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KEY FINDINGS RELATIVE TO TROLLEY HANDLING

- The standard cadaver trolleys generated unacceptable forces under almost all conditions and are considered a musculoskeletal hazard to the staff using them.

- The acceptable limits for pushing a cadaver trolley are considered to be 10 kgf initial movement and 4kgf for ongoing or sustained movement-based on frequency of movement, distance and handle design.

- Designing a manual handling task for the smaller female-e.g 5th%ile is conservative but will mean 95% of females and all males will have the capability.

- Research is clear. Large diameter trolley wheels reduce forces for all trolley movement. They spread the weight over a larger surface area and therefore change the shape of the wheel less.
KEY FINDING

• Handling cadaver trolleys is a musculoskeletal hazard requiring control

PROPOSED CONTROL MEASURES:

– Short term control measure: employing casuals to assist with laboratory set up whilst trolley redesign being addressed.
– Investigate the option of using ‘smart mover’ (a motor drive unit) to move the trolleys.
– Trial different castors and sizes of wheels to reduce the manual force associated with trolley movement.
Trial 1 – Motorised ‘smart mover’ to move cadaver trolleys
Supplied by Service Assist – customised the attachment
Trial 1 – Smart mover

Trial still in process

• Reduced manual force requirement

However current observations include:

• Increase in physiological effort
• Increased time to set up/clear up laboratory → time critical activity
Trial 2 – change castor design: Rotacaster wheel

• A multi-directional wheel system. Enables movement in any direction without a traditional swivel mount. Greatly enhances trolley manoeuvrability capability and in turn reduces the level of force exerted by the user.

• An existing trolley was modified whilst preserving the current height to ensure it remained compatible with the cadaver racking system.

• This prototype was trialled by the users, however unfortunately it did not reduce the push/pull force required.

• Didn’t change the wheel size still have load weight concentrated over small wheels
Trial 3 – Change castor size

- Replace existing 125mm swivel castors with 200mm swivel castors with round profile polyurethane rubber tyres
- An existing trolley was modified whilst preserving the current height to ensure it remained compatible with the cadaver racking system.
- This prototype was trialled by the users, forces measured and feedback sought.
- Applying the 200mm castors effectively reduced the push/pull forces for the cadaver trolley under all conditions to an acceptable level.
### Location of force exertion

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<th>CASTORS</th>
<th>125mm</th>
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ADDITIONAL FINDINGS

• Force required to initiate trolley movement is considerably more when the wheels are pointed away from the direction of travel. Research undertaken by Lawson, Potiki & Watson 1993 found certain trolleys necessitated between 300 and 800 % more effort when the castors weren’t aligned in the direction of intended travel.

OTHER KNOWLEDGE

• Floor maintenance, castor maintenance, have a substantial effect on the forces experienced by the user and the life of the equipment.

• Pushing with good traction can generate as much as 50% more force than pushing with poor traction –implications for footwear
WHERE WE ARE AT:

• Continuing the trial of the motorised tug-has considerable application

• Replace 125mm castors with 200mm castors on all cadaver trolleys

• Engage casual staff during peak semester periods to assist with the setting up of the laboratory and ease.

• Apply stickers to heavier cadaver trolleys to indicate weight hazard.

• Provide staff with training in best practice trolley handling.

• Ensure castors are oriented in the direction of travel before moving
FUTURE CONSIDERATIONS

• Investigate the possibility of adding vertical handles to the cadaver trolleys to accommodate variation in user anthropometry

• Observe the need to preserve /maintain a sealed cover over the cadaver at all times.

• Implement a weight restriction policy for donated cadavers
CONCLUSION

• The motorised solution effectively reduced manual handling effort but increased the time requirement.

• Larger diametre casters reduced push pull forces under all circumstances.

• Appropriate trolley design/selection will enable most items to be moved safely with minimum risk of MSDs.

• Validated the effectiveness of sound safety practices.
ACKNOWLEDGEMENTS

• Anatomy Laboratory Manager and technical staff

• Head of Department – Anatomy and Neurosciences

• Service Assist - Manual and Materials Handling Specialists