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EMPLOYEE WELLNESS & SAFETY

INJURY PREVENTION

STAXI CHAIR ASSESSMENT

FINAL REPORT

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Background

The STAXI chair is a transport wheelchair that is designed for patient transport. The chair was reportedly designed to be easier to push and manoeuvre than a regular wheelchair due to the weight distribution in the base of the chair (4.2 times more weight distributed on the rear wheels as compared to the front wheels) and a full width horizontal handle bar. Due to the significant rearward displacement of the chair's weight, the chair will tip backward more easily than a standard chair, making it easier to manoeuvre over small curbs or similar obstacles. As a result of this decreased rearward stability, the chair incorporates an anti-tipping mechanism, consisting of a pair of small-diameter wheels protruding to the rear of the base of the chair. The chair also consists of an automatic braking system that is activated by releasing a hand-operated lever, which must be continuously depressed during operation to disengage the braking system.

This product was designed by staff at Sunnybrook Hospital in Toronto, Ontario. Other hospitals around North America are reported to use the chairs for short distance transport of their patients. The STAXI chair system purchased at Children's & Women's (C&W) Health Centre includes the base chair with options that include: seat padding, seat belts and, on some of the chairs, IV poles. The chair system purchased also includes a coin deposit attachment and racks for chair storage and return.

An ergonomic and safety assessment of the STAXI chair was requested by members of the HEU due to various concerns that were reported. Their concerns included questions regarding storage of the chairs, users of the chairs, ergonomic risk factors, and safety hazards related to use of the chairs. It was reported by the HEU rep that the chairs had been rejected by the British Columbia Cancer Agency (BCCA) due to issues surrounding worker discomfort, stability of the chairs when pushing over curbs, patient loading and unloading, and patient comfort.

As this assessment occurred prior to a full roll out of the chairs, user feedback was limited.

Objectives

This report will focus on an ergonomic and safety assessment of the STAXI chair. The goal of this report is to observe and identify risk factors in the use of the STAXI chairs, assess identified risk factors, and establish recommendations to reduce or eliminate the risk of musculoskeletal injury. Concerns regarding management of the chairs are not addressed directly. It is anticipated that these issues will be communicated directly between union and management.

Methodology

Various tools and methods were used to gather information and to develop appropriate recommendations:

1. **User Profile**: developed through discomfort surveys, injury records, work schedules, informal interviews regarding workers' concerns, opinions, and suggestions regarding the current system.

2. **Snook Tables (1991):** reference values used to determine the relative risk associated with pushing tasks. A Chatillon digital force gauge (FCE Series Medical Dynamometer) was used to measure pushing forces.

3. **WCB Risk Factor Identification Worksheet A and WCB Risk Factor Assessment Worksheet B (2001):** used to determine the level of risk associated with each of the risk factors for each of the subtasks as well as the level of risk due to combinations of subtasks. If the risk for injury is assessed to be "moderate" or "high", control measures must be implemented to eliminate, or if that is not practicable, minimize the risk for injury.

4. **Rapid Upper Limb Assessment (RULA):** a method for estimating the risks of work-related upper limb disorders by a systematic assessment of the worker's posture (McAtamney & Corlett, 1993). Awkward working postures, in combination with forces and static/repetitive postures were considered in the analysis of risks for injury. This tool was used to give priority (Action) levels for controlling risk factors.

   Explanation of RULA Action Levels:

   Action Level One (Score = 1 or 2): The posture is acceptable if it is not maintained or repeated for long periods of time.

   Action Level Two (Score = 3 or 4): Further investigation is needed and changes may be required (equivalent to a "low" risk for injury).

   Action Level Three (Score = 5 or 6): Investigation and changes required soon (equivalent to a "moderate" risk for injury).

   Action Level Four (Score = 7): Investigation and changes required immediately to prevent possible injury (equivalent to a "high" risk for injury).

5. **Comparison to Typical Portering Wheelchairs:** the following factors were measured and compared between the STAXI chair and a typical portering wheelchair to determine if there were any significant differences:
   - Push/pull forces
   - Lateral and rearward stability
   - Hand-grip diameter

   Note: For each of the factors listed above, except hand grip diameter, an average value was obtained from measurements taken over 5 trials.

Risk Factor Definitions

Repetitive motions
Tasks that are frequent or repetitive in nature increase fatigue levels and the chance for musculoskeletal injury. During repetitive cycles without adequate rest breaks the muscles and tendons may not be given sufficient time to properly recuperate, leading to fatigue and micro tears in the muscles that can lead to potential strains. Repetitive motions do not have to involve high force or awkward postures to pose a risk for injury, sometimes making them more difficult to identify as risk factors for injury.

Awkward postures
Awkward postures are postures that cause the worker to work outside of a neutral posture (WCB of BC, 1994). Body postures determine which joints and muscles are used in an activity and determine the level of force or stress placed on those particular areas (NIOSH, 1997). Working in awkward postures causes the affected muscles to exert more force than neutral postures, placing undue stress on the body (WCB of BC, 1994). Awkward postures by themselves do not necessarily place the worker at risk for injury; however, extreme awkward postures, or awkward postures combined with force, repetition, or static postures significantly increase the risk for injury.

Forceful exertions
Tasks that require the worker to use forceful exertions place higher loads on the muscles, tendons, ligaments and joints of the body than do non-forceful exertions (NIOSH, 1997). Forceful exertions also place greater physiological demands on the body, and increase the likelihood of accidents.

Duration
Duration refers to the amount of time spent performing a task that exposes the worker to a risk factor (NIOSH, 1997). Duration can either be continuous or intermittent. Risk factors that occur for short periods of time, but on a regular basis throughout the day, must be summed to give the total duration that those particular risk factors are subjected to. Continuous work is worse than intermittent work because the muscles are given no time to rest.

Contact stress
Contact stress occurs when parts of the body come into contact with hard or sharp objects. For example, desk edges and narrow handled tools can cause contact stress on the forearms and hands, respectively.

Static postures
Static postures are postures held for an extended period of time (30 seconds or greater). Holding a static body position can restrict blood flow to the affected area and prevent muscles from resting and recuperating.

Results

Satisfaction Survey

A total of 21 staff from 6 different areas of Children's and Women's Health Centre (Medical Day Unit (MDU), Children's Hospital, Day Surgery, Labour & Delivery, Emergency, and BCW) were surveyed in regards to their satisfaction in using the STAXI chair in comparison to a typical portering wheelchair. The survey included questions regarding ergonomics, staff and patient safety, patient comfort, and staff discomfort related to use of the STAXI chair.

Factor	*Much Worse (= 1)*	*Worse (= 2)*	*Equal (= 3)*	*Better (= 4)*	*Much Better (= 5)*	***Avg. Score***
Maneuverability	1	5	6	3	4	**3.2**
Effort to push	0	2	8	5	4	**3.6**
Comfort for the patient	2	6	6	3	2	**2.8***
Comfort for the person pushing	0	6	4	6	4	**3.4**
Ease of getting in/out	1	3	8	4	2	**3.2**
Stability	0	0	8	9	4	**3.8**
Patient Safety	0	7	5	6	3	**3.2**
Staff Safety	1	1	8	6	4	**3.6**
Overall	0	4	5	6	3	**3.5**

* **Note:** some of the staff who were surveyed had used the STAXI chair prior to the time that cushioning had been placed on the seat and back rest.

Summary

Results of the satisfaction survey indicated that, on the average, staff reported that the STAXI chair is easier to maneuver, requires less effort to push, is more comfortable to push, is easier for the patient to get into or out of, is more stable, and is safer for the patient and staff, as compared to a typical portering wheelchair. However, on the average, staff reported that the STAXI chair is less comfortable for the patient (see note above).

Pain or Discomfort

Results of the survey indicated that 2 out of 21 workers surveyed experienced pain or discomfort in the hand region and 2 experienced pain or discomfort in the shoulder region due to pushing the STAXI chair with one hand while pushing an IV pole with the opposite hand.

Additional Comments

Two out of 21 staff surveyed indicated that the automatic braking mechanism could be potentially unsafe for a pregnant woman who is not able to wear the seat belt.

Injury Reports

A review of injury statistics at C&W Health Centre revealed no related injuries recorded for porters who used the STAXI chair system.

Task Analysis

Usage of the STAXI chairs varies between departments and staff using the chairs.

Department	Average Number of trips per shift per worker	Average duration per trip (min)	Total duration* per shift (min)
MDU	1	5-10	5-10
BCCH Porters	n/a	n/a	n/a
Day Surgery	2	5-10	10-20
Labour and Delivery	10	2-5	20-50
Emergency	n/a	n/a	n/a
BCW	n/a	n/a	n/a

*** Note:** estimated by staff during interviews.

Additional Tasks

Porters who use the STAXI chairs are also responsible for moving beds, stretchers, etc, which accounts for approximately 75% of their shift, or approximately 5 hours total per 7.5 hour shift.

Stability

Stability of both the STAXI chair and a typical portering wheelchair (W/C) was measured by determining the force required to tip a loaded chair in a lateral (side-to-side) or rearward direction.

Measurement	Chair	Load (kg)	Height above seat	Average
Lateral force (kg)	STAXI	55	16”	23.4*
Lateral force (kg)	W/C	55	16”	14.6
Rearward force (kg)	STAXI	55	16”	8.4*
Rearward force (kg)	W/C	55	16”	14.4

*** p<0.01**

Summary

Results indicated that the STAXI chair was significantly ($p<0.01$) more stable in the lateral direction but significantly ($p<0.01$) less stable in the rearward direction as compared to a typical portering wheelchair. The lower stability found for the STAXI chair in the rearward direction is associated with the rearward displacement of the weight of the base of the STAXI chair, which helps to increase maneuverability. An anti-tipping mechanism is attached to the rear of the STAXI chair to prevent over-tipping of the chair (see photo below).

Anti-tipping mechanism

Hand-grip Diameter

Typical portering wheelchair = 1.0”

STAXI chair = 2.5”

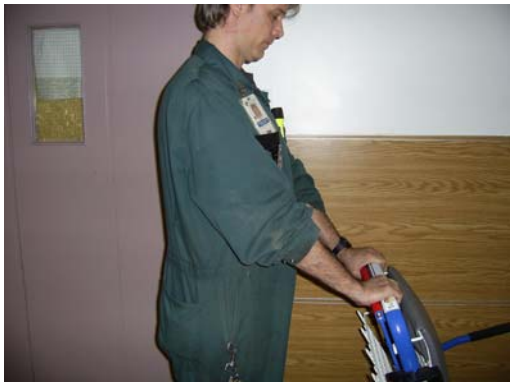
Summary

The hand-grip diameter for the STAXI chair is 43% greater than the recommended maximum ergonomic hand-grip diameter of 1.75”. As a result, the fingers and thumb are placed in an awkward posture when pushing the chair.

Posture

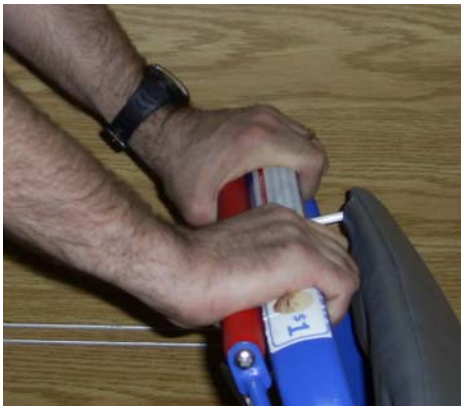
Ht. of worker	Trunk Flexion (deg)	Wrist Extension (deg)
5'5"	0	30
6'1"	0	45

Trunk Posture (5'5")



Trunk Posture (6'1")

Wrist Posture (5'5")



Wrist Posture (6'1")

Summary

There was no difference in trunk posture between an average size worker (5'5") and a tall worker (6'1"). There was no noticeable trunk flexion in either case.

The wrist posture for an average size worker was approximately 30 degrees of extension compared to 45 degrees for the tall worker. In addition, the forearms are in full pronation. This results in a somewhat awkward posture for the tall worker.

During one-handed pushing, it was noticed that there was approximately 5-10 degrees of ulnar and radial wrist deviation (side-to-side movement).

Hand-grip Forces (STAXI chair)

Measurement	Chair 1	Chair 2	Chair 3	Chair 4	Chair 5	Average
Initial force (kg)	1.6	1.0	1.4	1.5	1.1	**1.3**
Sustained force (kg)	2.8	1.8	2.3	2.4	2.0	**2.3**

Summary

The average sustained force required to hold the handle and automatic hand brake mechanism in a disengaged position is 2.3 kg. When pushing the chair with two hands, the average force per hand is therefore 1.15 kg. These forces are within recommended safe limits, as outlined by the WCB Risk Factor Identification Worksheet A.

Reduction of Hand-Grip Force

It was found that the hand-grip force could be reduced to approximately 1.2 kg by reducing the tension in the braking mechanism, while still allowing for full activation of the braking mechanism once the handle is released; this results in a reduction in hand-grip force on each hand to approximately 0.6 kg, which is nearly half the force experienced prior to reducing the spring tension.

Contact Stress

Contact stress is experienced on the thumb / fingers when pushing the STAXI chair due to the shape and hardness of the handles and sustained grip force of approximately 1 kg on each hand required to disengage the braking system while pushing the chair. Twice as much contact stress is experienced with one-handed pushing.

A force of 8.8 kg or greater acting on the worker's thumbs may be experienced when pushing the STAXI chair up an inclined surface (see Push/Pull Forces section). This force will also act on the worker's wrist, elbow, and shoulder region.

Push/Pull Forces

Measurement	Chair	Load (kg)	Location	Surface	Average
Initial push force (kg)	STAXI	55	Indoors	Flat	**2.0**
Initial push force (kg)	W/C	55	Indoors	Flat	**2.0**
Sustained push force (5 s) (kg)	STAXI	55	Indoors	Flat	**1.0**
Sustained push force (5 s) (kg)	W/C	55	Indoors	Flat	**1.0**
Initial push force (kg)	STAXI	55	Outdoors	Sloped	**9.5***
Initial push force (kg)	W/C	55	Outdoors	Sloped	**8.4**
Sustained push force (5 s) (kg)	STAXI	55	Outdoors	Sloped	**8.8***
Sustained push force (5 s) (kg)	W/C	55	Outdoors	Sloped	**7.8**

*** p<0.05**

Summary

Results indicated that there was a slight, but significant ($p<0.05$), difference between the pushing forces up an inclined surface (outdoor wheelchair access ramps), with the STAXI chair requiring approximately 1 kg more force. This is most likely due to the heavier weight of the STAXI chair (50 lbs vs. 36 lbs).

RULA and the WCB Risk Factor Identification and Assessment checklists indicate that the risk for injury due to 2-handed pushing on a flat or inclined surface, in combination with other tasks, is rated “low”, and therefore within acceptable safe limits.

Results of the Rapid Upper Limb Assessment (RULA) for one-handed pushing on a flat surface where lateral maneuvering is involved, in combination with other tasks, indicated a low risk for injury (RULA Score = 4; Action Level = 2).

One-handed pushing on a flat surface

Results of the Rapid Upper Limb Assessment (RULA) for one-handed pushing up an inclined surface indicated a moderate risk for injury to the hand, wrist, and shoulder (RULA Score = 6; Action Level = 3).

One-handed pushing on an inclined surface

Conclusion

The high hand-grip forces experienced while pushing the STAXI chair with one hand and an IV pole with the opposite hand, in combination with an oversize grip, contact stress on the thumb, ulnar and radial wrist deviation, along with multi-directional resistive forces between 2 and 10 kg experienced to maneuver the chair up an inclined surface may result in a moderate risk for injury to the hand, wrist, or shoulder region.

Safety Issues

1. Potential for hand brake mechanism to become activated during operation if the palms of the operator's hands slip off the handle, if using a thumbless grip (especially true for taller workers). This will result in a sudden stop, which may jar the patient sitting in the chair. If the patient is a pregnant woman who is not wearing a seat belt, the patient may slide forward on the chair in this situation (potentially dangerous if moving down an inclined surface).

Thumbless grip

2. Fingers may get caught in between IV pole attached to the chair and side arm of chair when the arm of the chair is raised due to the close proximity of the pole and the side arm of the chair.

IV pole attached to side of chair

Summary of Results

It is evident from the risk assessment and worker reports of pain and discomfort that one-handed pushing of the STAXI chair up an inclined surface may place the worker at moderate risk for injury to the hand, wrist, or shoulder region. As a result, the appropriate control measures should be implemented to minimize the risk of injury.

Use of a thumbless grip may result in accidental application of the braking mechanism, which may pose a safety hazard if the patient is a pregnant woman who is not wearing a seat belt and is being transported down an inclined surface.

The worker's fingers may get caught in between IV pole attached to chair and side arm of chair when the arm of the chair is raised due to the close proximity of the pole and the side arm of the chair.

Recommended Control Measures

1. Reduce the hand-grip force required to disengage the braking mechanism by adjusting the spring tension to the lowest level possible.

2. Always push the chair using both hands. If an IV pole is required, it should be attached to the support on the side of the STAXI chair.

3. Padding should be placed around the IV pole attached to the chair to minimize the risk of injury in the event that the fingers are positioned between the side arm and pole when the side arm is raised.

4. Use a thumbless grip to reduce the contact stress on the thumb. Ensure that the hand brake is securely held with this type of grip. Otherwise, use a full grip to ensure that the braking mechanism doesn't accidentally become activated during use, especially when moving down inclined surfaces.

References

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STAXI Chair Assessment – Results

Ergonomic Risk Factors Identified:

1. Oversize hand grip required (approximately 50% greater than standard grip diameter) to hold handle and automatic hand brake mechanism in disengaged position (red handle in photo).

2. Contact stress on thumb / fingers from handles and sustained grip force of approximately 1 kg on each hand required to disengage braking system while pushing chair with both hands.

3. Sustained grip force of approximately 2 kg while pushing chair with one hand and IV pole with opposite hand. Hand-grip force in excess of 2 kg required when maneuvering chair around turns or up inclined surfaces with one hand while pushing IV pole with opposite hand (2 out of 21 workers surveyed experienced pain or discomfort in the hand region while another 2 experienced pain or discomfort in the shoulder region due to this task).

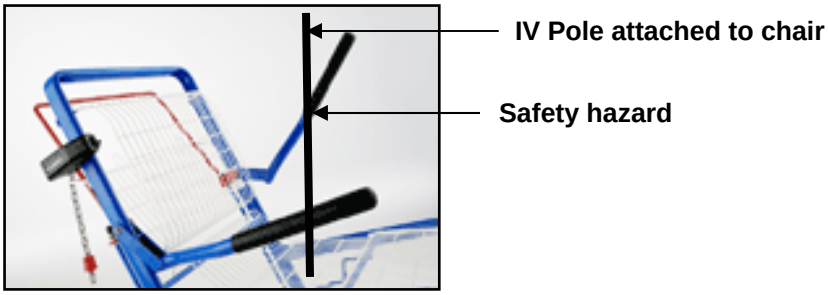
Conclusion:

The high hand-grip forces experienced while pushing the Staxi chair with one hand and an IV pole with the opposite hand, in combination with an oversize grip, contact stress on the thumb, ulnar and radial wrist deviation, along with multi-directional resistive forces experienced to maneuver the chair may result in a risk for injury to the hand, wrist, or shoulder region.

Safety Issues:

1. Potential for hand brake mechanism to become activated during operation if the palms of the operator's hands slip off the handle, if using a thumbless grip (especially true for taller workers). This will result in a sudden stop, which may jar the patient sitting in the chair. If the patient is a pregnant woman who is not wearing a seat belt, the patient may slide forward on the chair in this situation (potentially dangerous if moving down an inclined surface).

2. Fingers may get caught in between IV pole attached to chair and side arm of chair when arm of chair is raised due to close proximity of pole and side arm of chair.



Recommendations:

1. Use a spring-like clip to hold the handle for the braking mechanism in place while operating the chair. This will significantly reduce the hand grip force required to push the chair and eliminate the potential for the braking mechanism to become accidentally activated during operation. The clip should be removed when the chair is not in operation to prevent the chair from rolling. The clip could be attached to a chain on the frame of the chair to prevent it from becoming misplaced.

2. Grasp the handles of the chair (with clip attached) using a thumbless grip to minimize the contact stress and strain on the tendons of the thumb and fingers.

3. Always push the chair using both hands. If an IV pole is required, it should be attached to the support on the side of the STAXI chair. In this case, the side arm of the STAXI chair should be locked in place to avoid the risk of catching the fingers in between the side arm and the IV pole.