Ergonomic Assessment in Private EMS & Fire Academy

Final Report

Jesse Pollak, Mina Terzioglu, Braeden Wong, and Michael Yung

ENP114, Tufts University
Prepared for: Professor Gary Leisk
December 18, 2023

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Introduction

i. Overview

The client, an experienced emergency medical technician (EMT), is currently serving as a private EMT at Tufts EMS (Emergency Medical Services). As of October 2023, this individual has joined the Topsfield Fire Department, taking on the role of an on-call firefighter, while being trained in the fire academy three days a week. In this new capacity, she is required to wear heavy protective gear, handle substantial equipment like ladders and stretchers, and engage in rescue operations that may involve forceful exertions in awkward postures. The nature of the work has prompted her to recognize ergonomic concerns, particularly considering her shorter stature and frame—she is 5’2”—which significantly influences how she navigates the workspace. As the individual continues to familiarize themselves with the demands of the profession, it becomes imperative to explore the specific challenges she faces, including any potential musculoskeletal injuries.

In our ongoing communication, the individual has expressed openness to sharing details about the pain points she experiences in her role. A conversation and discovery meeting were initiated to gain insights into her experiences, everyday tasks, and workspace difficulties. This report aims to provide a comprehensive understanding of the ergonomic considerations relevant to our client’s responsibilities by analyzing work-specific tasks that can pose risks, implementing techniques such as REBA, RULA, and the TuMeke risk assessment software.

ii. Musculoskeletal Disorders (MSDs)

MSDs are a prevalent issue in firefighters, due to the physically-demanding and dynamic nature of the job-specific activities and tasks. Some common on-duty injuries include sprain, strain, and muscle pains which account for 43–62% of all injuries as compared to burn injuries (7%), thermal stress (6%), and toxic gas inhalation (4%) (S. Wang and Y. Wang, 2001). Studies suggest that the particular areas of injury are lower back, shoulder, knee, and ankle which often results from biomechanical risk factors such as load carriage, awkward posture, forceful exertion, and repetitive movements (S. Wang and Y. Wang, 2001).

Another factor that affects MSDs in firefighters is the heavy and bulky personal protective equipment (PPE) that they are required to wear and carry, including turnout garments, self-contained breathing apparatus (SCBA), fire boots, helmet, and gloves (S. Wang and Y. Wang, 2001). These impose a considerable physical load on firefighters, limiting their movement and contributing to musculoskeletal trauma across various parts of the body while doing work-related tasks (S. Wang and Y. Wang, 2001).

It is important to note that newly recruited firefighters who have less on-the-job experience and training face a ten times higher risk of injury, a disparity attributed to a mismatch in physical capability versus applied tissue loading (S. Wang and Y. Wang, 2001). Considering discrepancy, careful focus on the ergonomic assessment, preventative measures, and interventions for recent additions to the firefighting force like our client is necessary.

The most common occurrence of musculoskeletal disorders (MSDs) among firefighters is attributed to the significant joint force and muscle strain required to counteract loads that impact the musculoskeletal system (bones, nerves, tendons, muscles, and ligaments). This required muscular counterbalance and resultant strain causes microscopic fatigue damage and cellular/extracellular deterioration (S. Wang and Y. Wang, 2001).

iii. Client Feedback and Task Discussion

Our client works as both a private EMS and an on-call firefighter/fire academy trainee. These roles demand that she perform tasks that pose a significant strain on her body, especially as a person of smaller stature. Throughout the discovery meeting with the client, particularly strenuous tasks were identified. The individual discussed the nature of her work in addition to specific tasks she must perform that pose difficulty, especially as a person of smaller stature. The following are tasks mentioned by our client that pose significant strain:

1. Loading a manual stretcher
2. Carrying a person on a stair chair
    a. Especially challenging in confined spaces like narrow stairways
3. Moving/rolling patients
4. Dragging an unresponsive person out of a hazardous situation
5. Simultaneously holding a halligan bar with a charged hose
    a. The hand grip of the individual is too small (not wide enough) and she is unable to hold onto both tools at the same time
6. Loading and rolling hoses
7. Pulling a charged hose line
8. Carrying a self-contained breathing apparatus (SCBA)
    a. Worn for several hours when training in the academy
    b. Entire weight is supported at the hips
    c. Length of client's torso causes SCBA to interfere with her other PPE

Tasks 1 and 2 were selected to proceed forward with the ergonomic assessments since they are more convenient to demonstrate in non-emergency conditions unlike the rest of the tasks which are more situation-dependent. Tasks 1 and 2 also involve a variety of body-related orderly actions with another human component (patients) and they were specifically mentioned to be especially challenging to our client. Having a smaller stature affects the intensity of the task for our client, considering the design of the tools such as stretchers and stair chairs. Videos specific to tasks 1 and 2 were provided by our client of which our analysis is highlighted in the following sections.

Ergonomic Assessment

i. Loading a Manual Stretcher

The client mentioned a variety of stretcher types including power stretchers and partial/fully manual stretchers. Using a manual stretcher is a particularly physically demanding task since it requires supporting the full weight of the patient as well as the stretcher itself. The footage provided by the client includes a power stretcher since the video was captured at a fire department which utilizes these mechanized stretchers; however, the power mechanism was turned off for the sake of the video to emulate a manual stretcher like the ones used at her EMS position. Additionally, the manual stretcher is more critical to assess considering the increased required biomechanical load and resultant awkward posture compared to a power stretcher. As an individual of smaller stature (5' 2"), the client expressed difficulties when lifting a stretcher to a height closer to her shoulders. Stretchers include a latch that secures the stretcher to the vehicle, but the user must lift the stretcher to the appropriate height to implement the latching mechanism. As a result, the client recalled that she often resorts to standing on her tiptoes to lift the stretcher to the appropriate height rather than lift the stretcher with her arms which is a strenuous posture. Although the stretcher has multiple places to grip at different heights, lower levels are still too high for the stature of the individual, resulting in a problematic coupling for shorter emergency responders.

See Appendix C for the image.

i.i Task Analysis

Based on our client interview as well as a video of her re-enacting her performance of the task, we created a hierarchical task analysis for the task of lifting the manual stretcher into the rear of an ambulance. The scope of this task analysis includes extending the stretcher wheels, resting the front of the stretcher in the ambulance, pushing the stretcher into the ambulance, and signaling that the stretcher is safely inside the ambulance. At the start of the task analysis, it is assumed that the patient is already placed in the stretcher and strapped in, the stretcher is carried to the back of the ambulance, and the ambulance back doors are already open.

See Appendix A for the full hierarchical task analysis diagram for lifting the manual stretcher into an ambulance.

i.ii Assessment Methods

For the ergonomic assessment of this task, we implemented REBA (Rapid Entire Body Assessment), RULA (Rapid Upper Limb Assessment), and NIOSH (National Institute for Occupational Safety and Health). We chose to use these assessments because they are comprehensive and systematic approaches to evaluating musculoskeletal stresses and potential risks associated with manual handling tasks. Both REBA and RULA provide a holistic examination of body postures and movements, taking into account factors like height, reach, and force exertion. REBA and RULA include multiple scoring criteria that culminate in a final risk assessment of the posturing being analyzed. Additionally, the NIOSH lifting equation can contribute valuable insights into the risk of injury associated with manual lifting tasks. The NIOSH Revised Lifting Equation is defined by three parameters—biomechanical, physiological, and psychophysical. Since lifting tasks cause work-related low back pain and disability,the NIOSH Revised Lifting Equation is a useful tool to analyze and prevent those potential injuries.

The complexity of loading stretchers, especially loaded stretchers that require the user to support the full weight of a patient, into vehicles presents a myriad of hazardous postures and challenges. Shorter individuals face unique difficulties due to the sheer disparity in weight and size of the stretcher being manipulated. These difficulties are exacerbated with stretchers that are designed with higher or lower points of contact that don't match the stature of the user.

i.iii Results

The following are the results of the REBA, RULA, and NIOSH scoring with an additional hazard assessment table and a brief interpretation as provided via TuMeke:

Assessment	Initial Score	Adjusted Score	Interpretation
REBA	9	12	Very high risk, implement changes
RULA	6	7	Investigate and implement change
NIOSH	-	5.19	Implement changes to task immediately

See Appendix C for the key frame for loading the manual stretcher.
See Appendix D, E, and F for the full REBA, RULA, and NIOSH results, respectively.

The results of our REBA assessment indicated an initial score of 9, however, adjusting the assessment sheet, the REBA score was updated to a score of 12 which indicates that the task is of very high risk and should be investigated immediately. With the RULA assessment, the TuMeke software similarly indicated a lower score of 6, however, after reviewing and adjusting the scores, a maximum score of 7 was found which indicates that the task should be investigated and changed immediately. Additionally, the NIOSH revised strain formula found a score of 5.19, indicating that the task is of very high risk and that changes should be made immediately to reduce the lifting index.

In the target keyframe, it was observed that all sections of the body experienced significant levels of strain. In both REBA and RULA analyses, the arms, neck, trunk, and legs were found to be in significant extension, often achieving maximum scores for each category. Additionally, significant loads from the weight of the stretcher contributed to high force/load scores. The results from both REBA and RULA assessments highlight that the task involves significant risk with various body parts experiencing substantial strain. The NIOSH score further emphasizes the urgency of making changes to reduce the lifting index. The observed extensions in arms, neck, trunk, and legs, coupled with the high force/load scores due to the stretcher's weight, indicate a critical need for immediate investigation and intervention to mitigate the identified risks and improve the ergonomic conditions of the task.

Considering biomechanical models and the distribution of a load on the body, lifting a load, in this case, a person and stretcher system, creates significant stress and hazards on the body. When lifting the load system up to the vehicle height, the client bent over from the hips to grab the stretcher at the original bottom height. In doing so, the center of gravity of the client was shifted forward towards the load system, further away from the L5/S1 vertebrae. The L5/S1 vertebrae acts as the fulcrum to the system, so shifting the center of gravity away from the vertebrae significantly increases the load moment on the lumbar spine. Additionally, this bent position causes the stretcher system to be almost a torso's length away from the L5/S1 vertebrae which creates a significant load moment on the lumbar spine. To lift the load in this position, the client is forced to stand up straight from this bent posture carrying both the load of her upper body as well as the load of the stretcher system to counter the load moment, relying solely on the client's back muscles. Lifting this significant load with only her back muscles as support causes substantial strain to her lumbar spine and L5/S1 vertebrae. This strain createsa high risk for lower back injury.

i.iv Ergonomic Interventions

Considering the results of scoring from various assessments and interpretations above, the following are realistic interventions to improve and reduce the hazard level based on the ergonomics of the work-related task for our client:

Hardware-Related Interventions

- Adjustable grip height, accommodating people of different stature
  - The client will be able to grasp the stretcher at a lower height which would allow for more comfortable stretcher manipulation and reduce overall strain
- Redesign handles with ergonomic considerations, incorporating features such as non-slip grips and contours for improved grasp and increased friction
- Increase the height of the stretcher stand to the height necessary to load it into the vehicle
  - Eliminates the need for the user to lift the stretcher as they push it into the vehicle—the user would only need to push the stretcher into the vehicle
- Retractable wheels to make it easier to push stretcher into ambulance
  - The client would push a button to raise wheels upward, then lower them again once stretcher is inside ambulance
- Ramp-based mechanism when loading the stretcher into the vehicle
  - Implementation of a foldable/extendable ramp as an attachment to the vehicle
  - Translate the action from lifting to pushing
- Automated pulley/tow system to assist with pulling the stretcher into the ambulance
- Using a power-load stretcher instead of a manual stretcher to reduce the load on the body.

Posture-Related Interventions

- Develop specialized training programs focusing on biomechanics and safe lifting techniques, teaching responders how to leverage their body's natural movements during stretcher lifting
- Holding the low-height grips as close to the body as possible to reduce load moment and resultant strain
- When lifting the stretcher from a low/ground position, the user should squat their legs and try to keep their back straight rather than bend over at the hips to reduce strain on the lumbar spine and allow the utilization of the body’s muscles holistically to lift rather than isolating the back muscles. This upright torso position would reduce REBA and RULA scores and reduce the overall hazard of performing this task.
  - By keeping their torso upright, the user would not need to have their neck in backward extension to look up, a strenuous position for the neck. The user would be able to keep their neck upright and in line with their torso to see ahead of them.
  - Hold the stretcher with arms as close to their natural resting position as possible when lifting, perhaps in between their squatted legs. This position would keep the stretcher system load close to the lumbar spine thus reducing the load moment and resultant required force to lift this load.

- Enhancing team coordination and communication during stretcher operation. Making sure that two operators move at the same time in a controlled manner and exert similar lifting force

ii. Carrying a Person on a Stair Chair

The task of using a stair chair is an essential part of emergency medical services and rescue operations, particularly when patients who are unable to walk down stairs from injury, illness, or other mobility issues need to be transported down staircases. As mentioned by the client, using stair chairs are relatively easy since they include a set of tracks that glide over the edges of the stairs, which allows for controlled movement and requires minimal lifting. The stair chair typically features handles at both the top and bottom, allowing for two operators to guide it. The operator at the top of the stair chair guides the direction and speed, while the person at the bottom bears the weight of the chair and the patient. The client usually prefers to be at the bottom position supporting the chair while holding her arms stretched. As feedback on the stair chair design, the client expressed that if the handles were at lower height it would have been easier to hold onto for shorter people like her. This indicates that she does not have sufficient grip, which is crucial for maintaining control of the chair, especially when descending.

See Appendix G for the image.

ii.i Task Analysis

Based on our client interview as well as a video of her re-enacting her performance of the task, we created a hierarchical task analysis for the task of carrying a stair chair downstairs (from the front, facing backward). The scope of this task analysis includes lifting the front of the stair chair, carrying it backward downstairs, placing it at the bottom of the stairs, and then moving out of the way. At the start of the task analysis, it is assumed that the patient is already placed in the stretcher and strapped in and that the stair chair is wheeled to the top of the stairs.

See Appendix B for the full hierarchical task analysis for carrying a stair chair downstairs.

ii.ii Assessment Methods

For the ergonomic assessment of this task, we implemented REBA (Rapid Entire Body Assessment), RULA (Rapid Upper Limb Assessment), and NIOSH (National Institute for Occupational Safety and Health) as per the previously analyzed task. See section **i.ii** for full descriptions of these methods.

For stair chairs, the consideration of body positions, grip heights, and the mode of operation, as highlighted in the provided video, can be systematically assessed using these tools. By employing REBA, RULA, and NIOSH, we aim to identify potential ergonomic hazards and design interventions that enhance the safety and well-being of firefighters, particularly those of shorter stature, when performing stretcher and stair chair loading tasks.

ii.iii Results

The following are the results of the REBA, RULA, and NIOSH scoring with an additional hazard assessment table and a brief interpretation as provided via TuMeke:

Assessment	Initial Score	Adjusted Score	Interpretation
REBA	4	8	High risk, change soon
RULA	3	7	Investigate and implement change
NIOSH	-	3.42	Implement changes to task immediately

See Appendix G for the key frame for carrying a person on a stair chair.

See Appendix H, I, and J for the full REBA, RULA, and NIOSH results, respectively.

Initially, our REBA assessment showed a score of 4. However, after revising the assessment, the adjusted score increased to 8, signaling that the task poses a high risk and requires prompt changes. Similarly, the TuMeke software's RULA assessment initially indicated a lower score of 3. However, after reviewing and adjusting the scores, we found a maximum score of 7 which indicates that the task should be investigated and changed immediately. Furthermore, the NIOSH revised strain formula yielded a score of 3.42, emphasizing the task's very high risk and the need for immediate changes to lower the lifting index.

In the stair chair task's target keyframe, the client demonstrated a relatively balanced posture, resulting in less strain on her arms, trunk, and legs. However, her neck experienced significant strain as she positioned herself at the front end of the stair chair. This required her to over-extend her neck to avoid falling over. Additionally, significant loads from the weight of the stair chair and patient contributed to high force/load scores.

We can also consider biomechanical models and the distribution of a load on the body to assess specific pain points in completing this task. Lifting and manipulating a person’s dead weight is already strenuous on the body from the considerable load itself, and having to counteract this large load with unbalanced/awkward postures can exacerbate the difficulty of the task and increase the hazard on the body. Heavy loads cause a significant mechanical load moment transmitted to the lumbar spine, particularly impacting the L5/S1 vertebrae, a common cause for lifting-related injuries. Carrying loads further away from the body and the L5/S1 vertebrae increases the load moment of the object and therefore increases the strain on the body. When manipulating large loads one should hold the load close to the body to reduce the load moment and strain on the L5/S1 vertebrae. While guiding a person downstairs on a stair chair, the user in the bottom position is forced to hold the coupling of the load wherever it lands near their body. In the analysis of this task, our client is in this bottom position; however, due to her shorter stature, the load coupling lands at chest height so she is forced to counteract this load at an awkward position. Carrying this significant load at shoulder height forces our client to hold the load out in front of her body which results in a significant load moment on her lumbar spine. The height of this load also isolates the counteractive force on her upper body and arms which increases the strain to these areas.

Additionally, the client's feedback regarding the handle height is critical. If the handles are too high for a shorter person like her, it can result in an uncomfortable and potentially hazardous coupling, which affects her balance and increases strain when doing the task. Descending the stairs and moving backwards is already challenging and not as stable and controlled, so she has to be providing stability to her body from other aspects as much as possible.

ii.iv Ergonomic Interventions

Considering the results of scoring from various assessments and interpretations above, below are some realistic interventions to improve and reduce the hazard level of the ergonomics of the work-related tasks for our client.

Hardware-Related Interventions

- Adjustable grip height, accommodating people of different stature
  - The client will be able to grasp the stretcher at a lower height
- Adjusting handle length: similar to the mechanism utilized in palanquins where two users carry a person using long handles adjacent to their bodies at their side.
  - Integrate extendable handles onto the stair chair so that the user can hold the stair chair at their side and can carry the patient facing forward rather than backward.
- Alter stair chair handles so the user can hold it vertically rather than horizontally and can avoid twisting or flexing their wrist.
- Redesign handles with ergonomic considerations, incorporating features such as non-slip grips and contours for improved grasp and increased friction.
- Rear-view mirror attachment to the stair chair, allowing the individual at the front of the stair chair to see behind them without twisting their neck/body.

Posture-Related Interventions

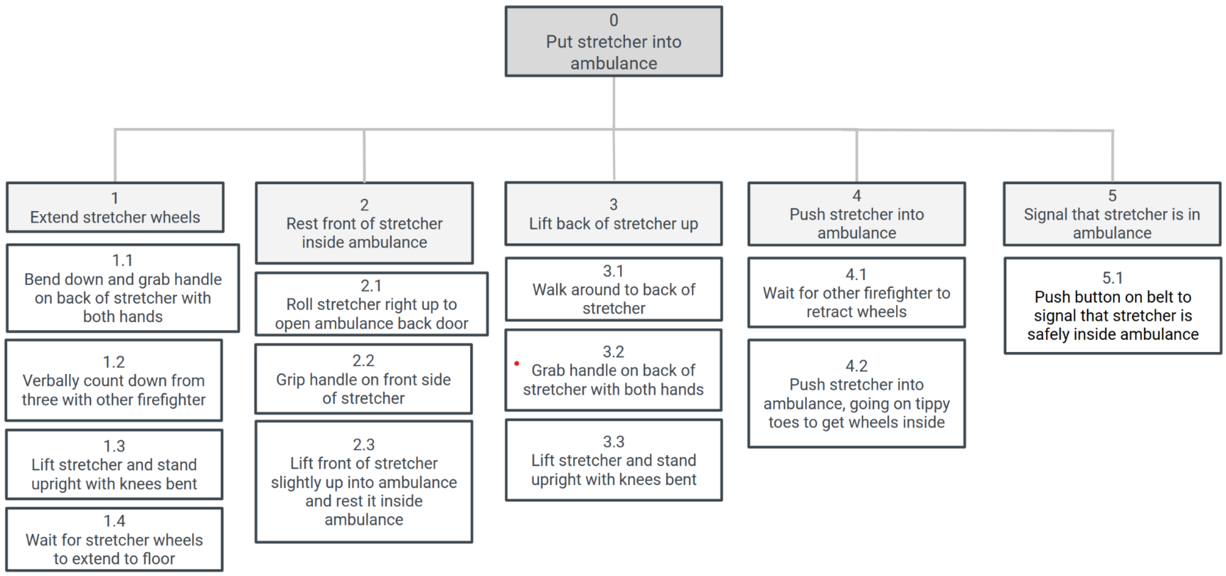
- Change the direction the client is facing when carrying the patient. Both individuals should be facing forward.
- Enhancing team coordination and communication during stair chair operation. Making sure that the two operators move at the same time in a controlled manner and exert similar lifting force. Increased communication would prevent the bottom user from having to turn their head to see forward and thus reduce the resultant neck strain.
- The client could switch positions to be the operator above to guide the direction and speed. As the bottom user, the client's height forces her to hold the stair chair at an awkward height causing strain on the arms. As the top user, the client can hold the stair chair at a more comfortable and less strenuous height.
- Develop training programs focusing on biomechanics to educate users on the optimal posture for stair chair operation.
- Explore design modifications that allow users to adjust the height at which the load couples with their body.

References

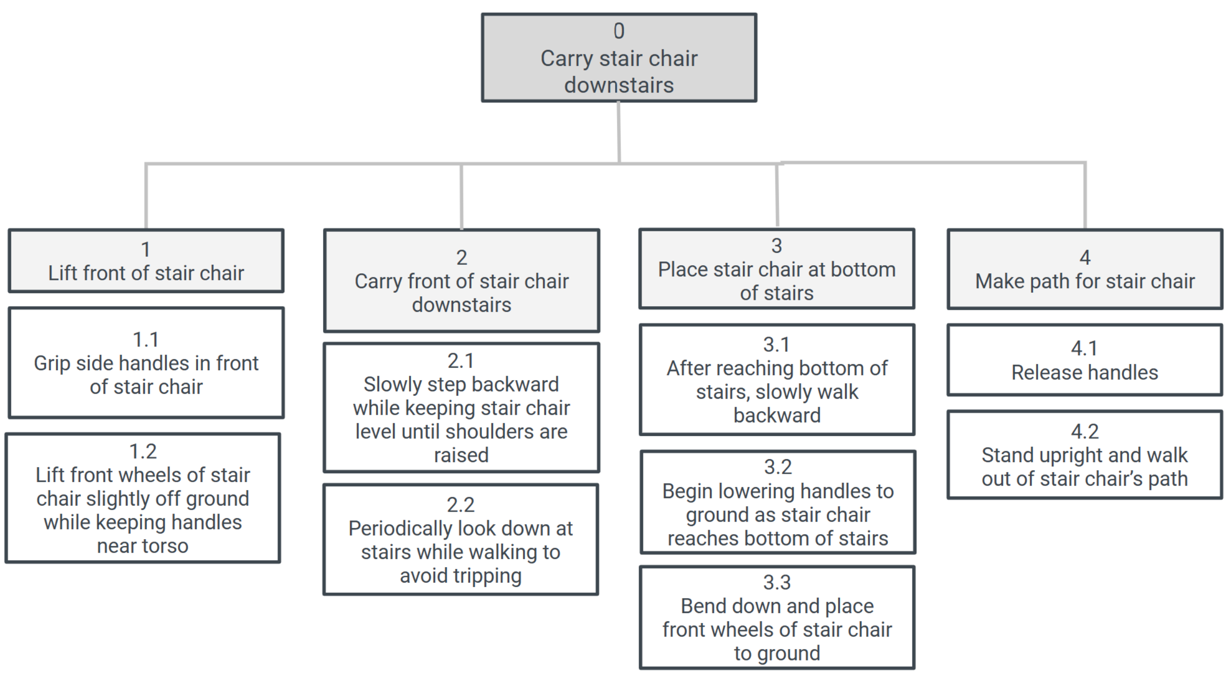
Wang, S., & Wang, Y. (2022). Musculoskeletal model for assessing firefighters' internal forces and occupational musculoskeletal disorders during self-contained breathing apparatus carriage. *Safety and Health at Work*, *13*(3), 315–325. https://doi.org/10.1016/j.shaw.2022.03.009

Appendix

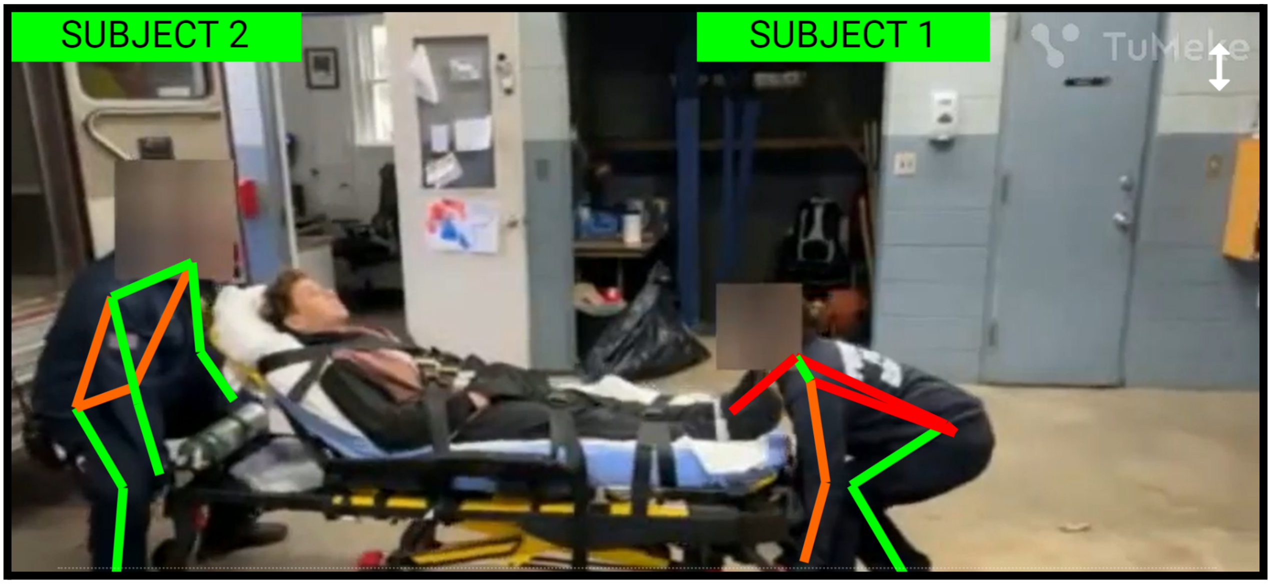
Appendix A: Task Analysis: Loading a Manual Stretcher Into Ambulance (from back)



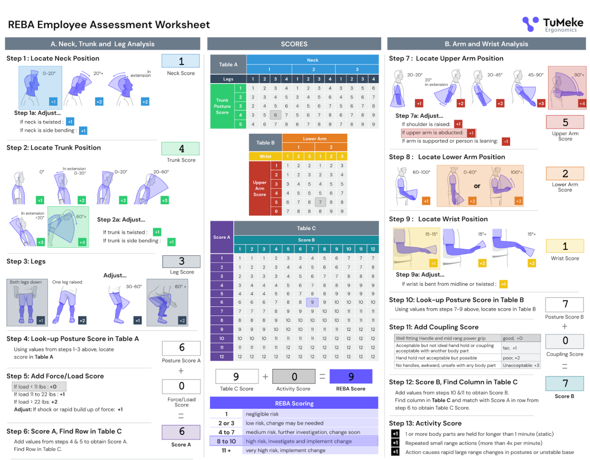
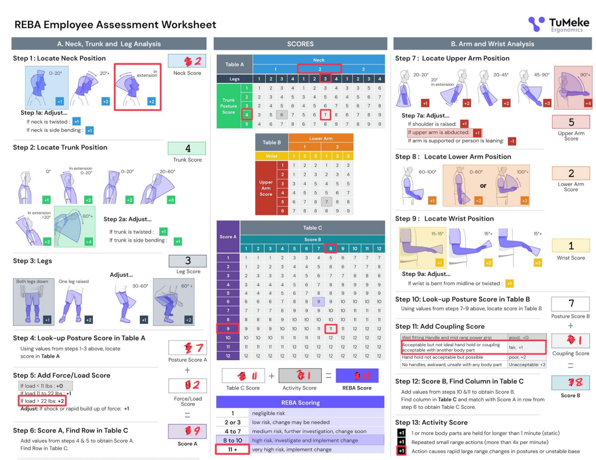
Appendix B: Task Analysis: Carrying a Person on a Stair Chair Downstairs (from front, facing backward)



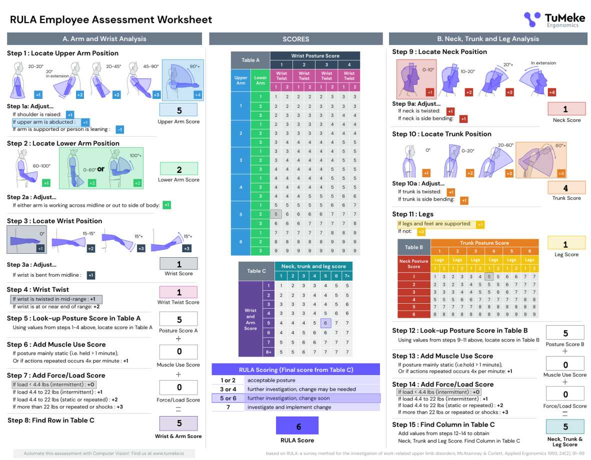
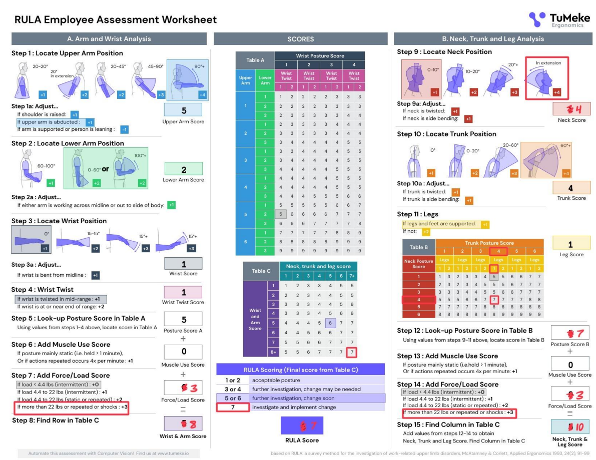
Appendix C: Key Frame for Loading a Manual Stretcher



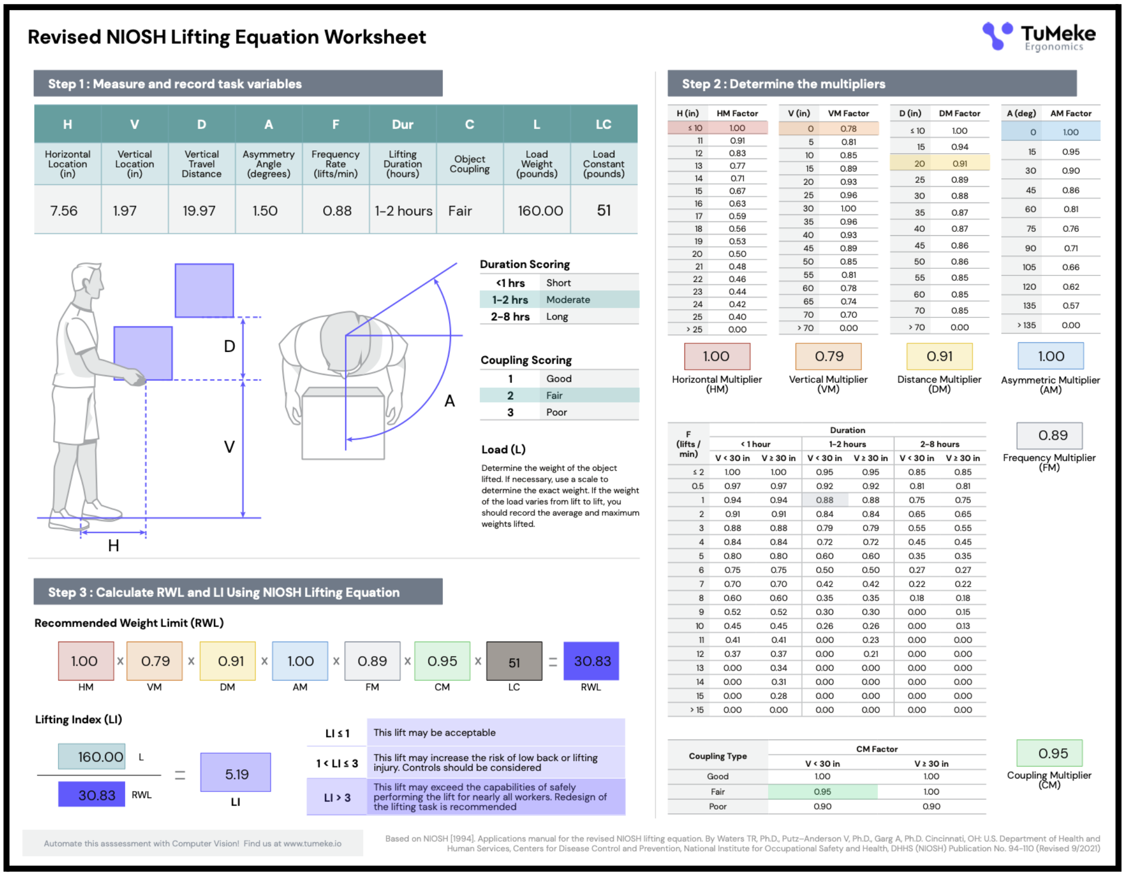
Appendix D: REBA Assessment for Loading a Manual Stretcher

Tumeke Assessment	Adjusted Assessment
REBA Score: 9 (high risk)	**Adjusted REBA Score: 12 (very high risk)**
	

Appendix E: Rula Assessment for Loading a Manual Stretcher

Tumeke Assessment	Adjusted Assessment
RULA Score: 6 (further investigation)	**Adjusted RULA Score: 7 (investigate + implement change)**
	

Appendix F: NIOSH Revised Lifting Equation for Loading a Manual Stretcher



Revised NIOSH Lifting Equation Worksheet

TuMeke Ergonomics

Step 1 : Measure and record task variables

H	V	D	A	F	Dur	C	L	LC
Horizontal Location (in)	Vertical Location (in)	Vertical Travel Distance	Asymmetry Angle (degrees)	Frequency Rate (lifts/min)	Lifting Duration (hours)	Object Coupling	Load Weight (pounds)	Load Constant (pounds)
7.56	1.97	19.97	1.50	0.88	1-2 hours	Fair	160.00	51

Duration Scoring

<1 hrs	Short
1-2 hrs	Moderate
2-8 hrs	Long

Coupling Scoring

1	Good
2	Fair
3	Poor

Load (L)

Determine the weight of the object lifted. If necessary, use a scale to determine the exact weight. If the weight of the load varies from lift to lift, you should record the average and maximum weights lifted.

Step 2 : Determine the multipliers

H (in)	HM Factor
≤ 10	1.00
11	0.91
12	0.83
13	0.77
14	0.71
15	0.67
16	0.63
17	0.59
18	0.56
19	0.53
20	0.50
21	0.48
22	0.46
23	0.44
24	0.42
25	0.40
> 25	0.00

1.00 Horizontal Multiplier (HM)

V (in)	VM Factor
0	0.78
5	0.81
10	0.85
15	0.89
20	0.93
25	0.96
30	1.00
35	0.96
40	0.93
45	0.89
50	0.85
55	0.81
60	0.78
65	0.74
70	0.70
> 70	0.00

0.79 Vertical Multiplier (VM)

D (in)	DM Factor
≤ 10	1.00
15	0.94
20	0.91
25	0.89
30	0.88
35	0.87
40	0.87
45	0.86
50	0.86
55	0.85
60	0.85
70	0.85
> 70	0.00

0.91 Distance Multiplier (DM)

A (deg)	AM Factor
0	1.00
15	0.95
30	0.90
45	0.86
60	0.81
75	0.76
90	0.71
105	0.66
120	0.62
135	0.57
> 135	0.00

1.00 Asymmetric Multiplier (AM)

F (lifts / min)	Duration					
	< 1 hour		1-2 hours		2-8 hours	
	V < 30 in	V ≥ 30 in	V < 30 in	V ≥ 30 in	V < 30 in	V ≥ 30 in
≤ 2	1.00	1.00	0.95	0.95	0.85	0.85
0.5	0.97	0.97	0.92	0.92	0.81	0.81
1	0.94	0.94	0.88	0.88	0.75	0.75
2	0.91	0.91	0.84	0.84	0.65	0.65
3	0.88	0.88	0.79	0.79	0.55	0.55
4	0.84	0.84	0.72	0.72	0.45	0.45
5	0.80	0.80	0.60	0.60	0.35	0.35
6	0.75	0.75	0.50	0.50	0.27	0.27
7	0.70	0.70	0.42	0.42	0.22	0.22
8	0.60	0.60	0.35	0.35	0.18	0.18
9	0.52	0.52	0.30	0.30	0.00	0.15
10	0.45	0.45	0.26	0.26	0.00	0.13
11	0.41	0.41	0.00	0.23	0.00	0.00
12	0.37	0.37	0.00	0.21	0.00	0.00
13	0.00	0.34	0.00	0.00	0.00	0.00
14	0.00	0.31	0.00	0.00	0.00	0.00
15	0.00	0.28	0.00	0.00	0.00	0.00
> 15	0.00	0.00	0.00	0.00	0.00	0.00

0.89 Frequency Multiplier (FM)

Coupling Type	CM Factor	
	V < 30 in	V ≥ 30 in
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

0.95 Coupling Multiplier (CM)

Step 3 : Calculate RWL and LI Using NIOSH Lifting Equation

Recommended Weight Limit (RWL)

HM		VM		DM		AM		FM		CM		LC		RWL
1.00	x	0.79	x	0.91	x	1.00	x	0.89	x	0.95	x	51	=	30.83

Lifting Index (LI)

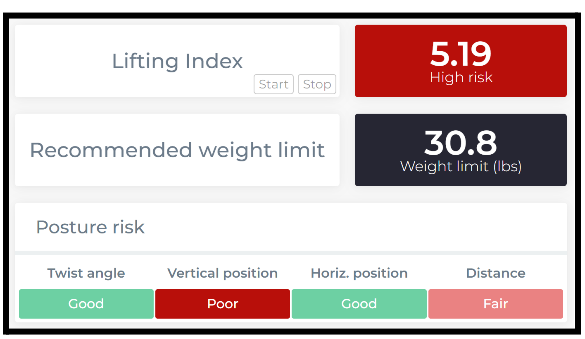
$$\frac{160.00 \text{ L}}{30.83 \text{ RWL}} = 5.19 \text{ LI}$$

LI ≤ 1	This lift may be acceptable
1 < LI ≤ 3	This lift may increase the risk of low back or lifting injury. Controls should be considered
LI > 3	This lift may exceed the capabilities of safely performing the lift for nearly all workers. Redesign of the lifting task is recommended

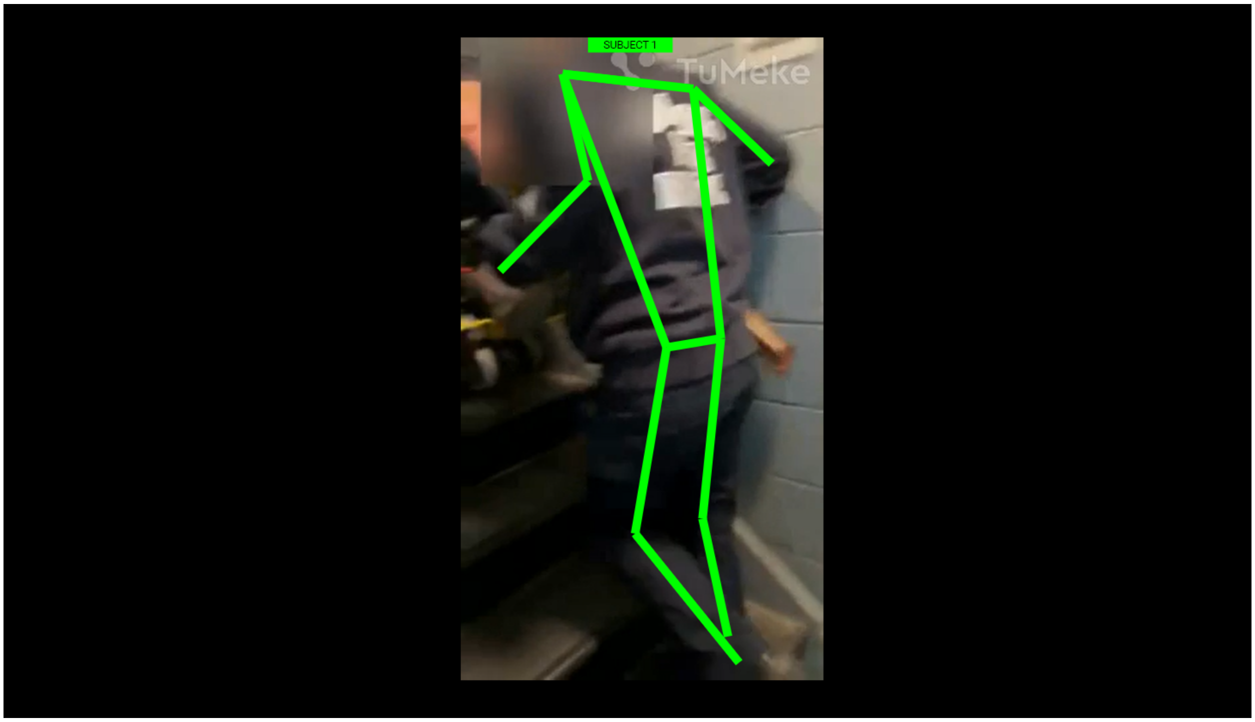
Automate this asssessment with Computer Vision! Find us at www.tumeke.io

Based on NIOSH [1994]. Applications manual for the revised NIOSH lifting equation. By Waters TR, Ph.D., Putz-Anderson V, Ph.D., Garg A, Ph.D. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-110 (Revised 9/2021)

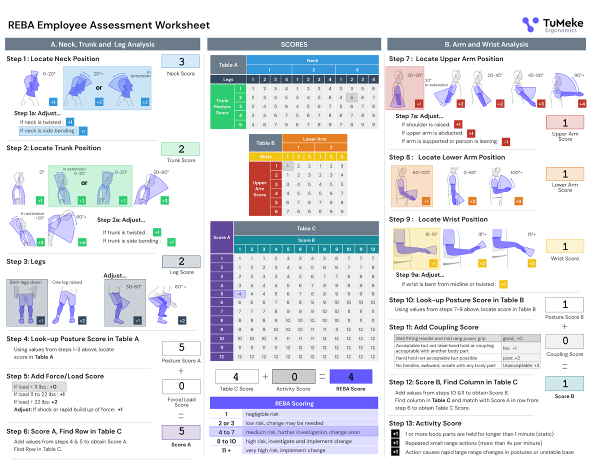
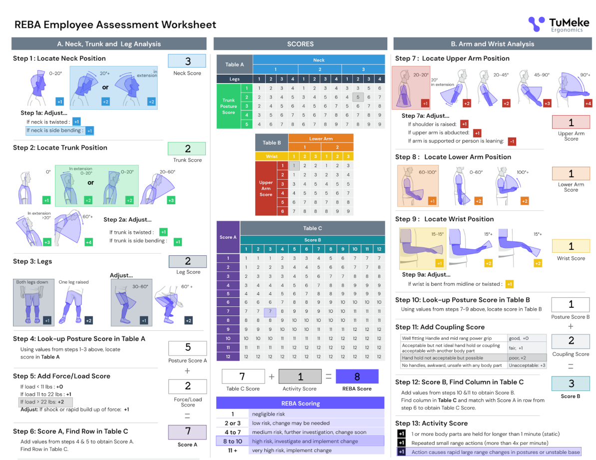
LI ≤ 1.00	Very Low Risk	No action required for the healthy population
1.00 < LI ≤ 1.50	Low Risk	Pay attention to low frequency/high load conditions and to extreme or static postures; consider efforts to lower LI below 1.00
1.50 < LI ≤ 2.00	Moderate Risk	Redesign tasks and workplaces according to priorities to reduce LI
2.00 < LI ≤ 3.00	High Risk	Changes to task to reduce LI should be a high priority
LI > 3.00	Very High Risk	Changes to task to reduce LI should be made immediately



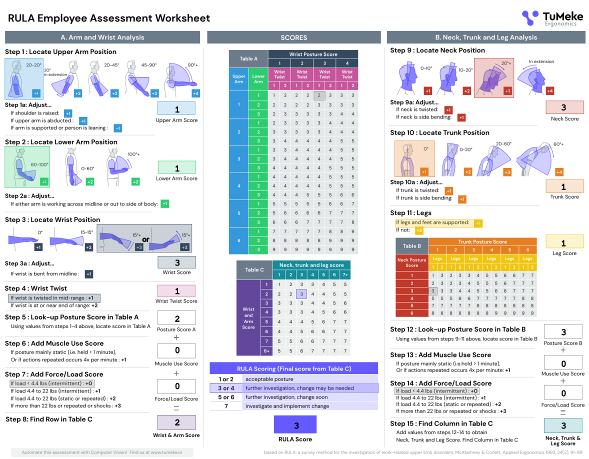
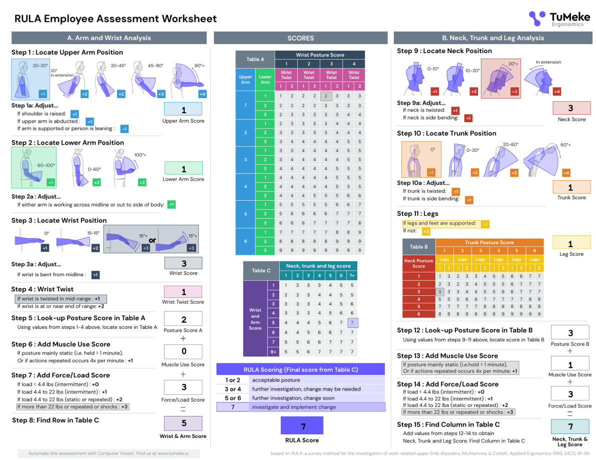
Appendix G: Key Frame for Carrying a Person on a Stair Chair



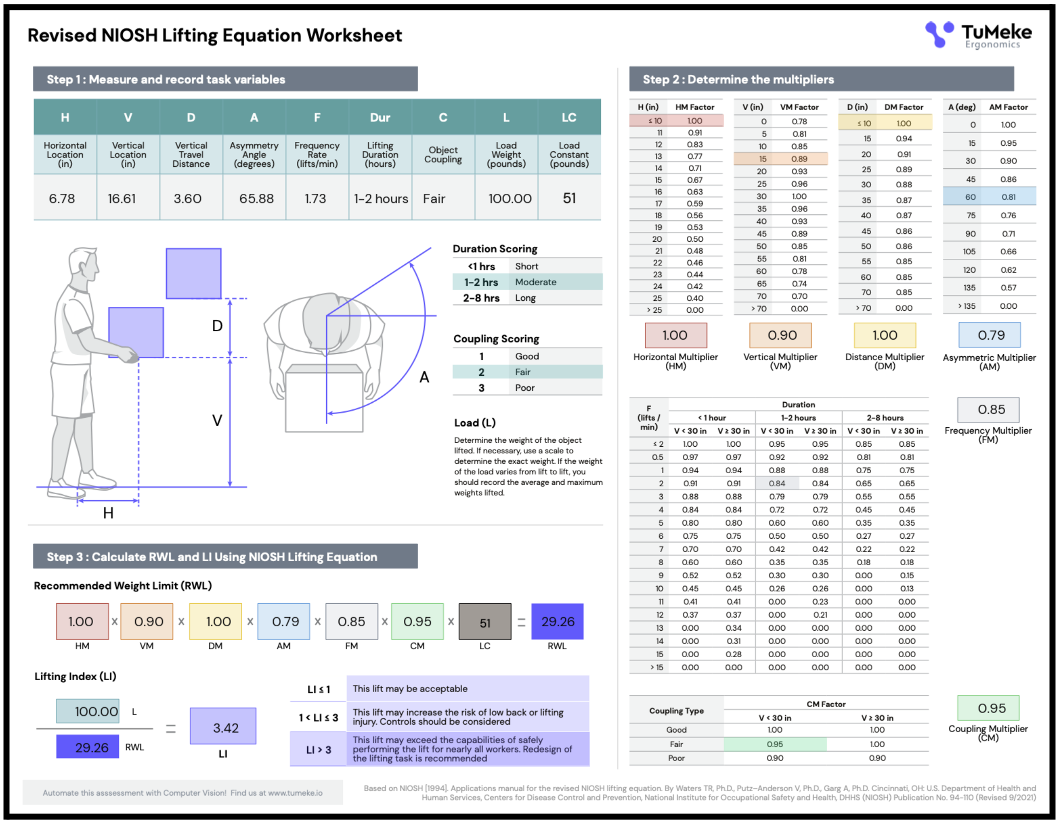
Appendix H: REBA Assessment for Carrying a Person on a Stair Chair

Tumeke Assessment	Adjusted Assessment
REBA Score: 4 (medium risk)	**Adjusted REBA Score: 8 (high risk)**
	

Appendix I: RULA Assessment for Carrying a Person on a Stair Chair

Tumeke Assessment	Adjusted Assessment
RULA Score: 3 (further investigation)	**Adjusted RULA Score: 7 (investigate + implement change)**
	

Appendix J: NIOSH Revised Lifting Equation for Carrying a Person on a Stair Chair



LI ≤ 1.00	Very Low Risk	No action required for the healthy population
1.00 < LI ≤ 1.50	Low Risk	Pay attention to low frequency/high load conditions and to extreme or static postures; consider efforts to lower LI below 1.00
1.50 < LI ≤ 2.00	Moderate Risk	Redesign tasks and workplaces according to priorities to reduce LI
2.00 < LI ≤ 3.00	High Risk	Changes to task to reduce LI should be a high priority
LI > 3.00	Very High Risk	Changes to task to reduce LI should be made immediately