Finnish Institute of Occupational Health

Comparison study

The effect of patient transport stretchers on work ergonomics among paramedics

Risto Toivonen, Research Engineer, M.Sc. Tech.

Virpi Fagerström, Researcher, M.H.Sc., occupational physiotherapist

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1. Introduction

The work of paramedics is physically demanding. Persons involved in paramedic work list moving, lifting and carrying patients in difficult conditions as the most strenuous work phases (Vehmasvaara 2004). The physical load factors have a clear connection to low back symptoms and problems reported by both males and females. Among females, the physical load factors have also caused symptoms in the neck-shoulder area (Aasa et al. 2005). Studies have indicated that the mortality rate is higher among ambulance personnel, they suffer more work-related accidents and retire for health reasons more often than other social and health care professionals (Stereund 2006).

The physical load factors in paramedic work comprise lifting and moving heavy objects, along with difficult working postures (Videman 2005, Vehmasvaara 2004). Individual attributes and factors, such as physical fitness, obesity, genetic makeup, height, muscular strength and age, all have an effect on how a paramedic experiences the physical load factors and whether or not they cause musculoskeletal disorders. For example, smoking and heavy alcohol consumption have been discovered to be connected to the occurrence of low back problems (Nelson 2006). Furthermore, each paramedic's patient moving skills (Donbaek et al. 2000), time spent working (Videman 2005) and psychosocial factors (Simon et al. 2008) affect the occurrence of musculoskeletal disorders.

Musculoskeletal disorders caused by patient handling can be prevented by improving work ergonomics, such as increasing the use of auxiliary equipment. Research strongly indicates the benefit of procedures where paramedics are instructed in patient handling and the use of auxiliary equipment (Bos et al. 2006). Measures that improve ergonomics are more efficient in reducing sick days caused by musculoskeletal disorders (Pompeii et al. 2009, Tullar et al. 2010, Lim et al. 2011) than measures that instruct workers in individual methods or lifting techniques (Martimo et al. 2008).

In paramedic work, patients are normally moved on stretchers; and when on stairs, possibly with the use of carrying chairs. Ergonomic and well-designed equipment can greatly facilitate the physically demanding work of transportation (Conrad et al. 2008). Nevertheless, there are obvious shortcomings in the ergonomics of patient transport stretchers, and different stretchers have not been found to affect the physical strain of paramedics (Kluth & Strasser 2006).

Moving and transporting patients on stretchers is known to be one of the most difficult tasks paramedics are faced with (Vehmasvaara 2004). Yet the equipment solutions of different stretcher manufacturers are very similar. Patient transfer and transport stretchers often comprise a transport bed as well as a frame whose wheeled legs fold under the bed when the stretcher is loaded onto an ambulance (Kluth & Strasser, 2006). In order to reduce the workload of paramedics, the stretcher slides into the ambulance by means of a loading ramp. In difficult environments such as narrow stairways, paramedics carry patients on the transport bed until the environment allows the base to be connected to the transport frame with wheels.

Pensi Rescue Oy has developed a patient transport stretcher (the Pensi 2000MA) where the wheel-mounted transport frame is integrated into the bed and the stretcher is loaded into a vehicle with an electrically operated Ergomy® loading aid. The purpose of this study is to determine the effect of different patient transport stretchers on the physical work strain and ergonomics of paramedics.

2. Research questions and aim of the study

The study aimed to determine the effect of different patient transfer and transport stretchers on the physical work strain and ergonomics of paramedics. The goal was to develop tools for patient transport that would reduce the paramedics' workload and help them to maintain their performance.

The more detailed research questions hinged on the effect of stretchers on the paramedics'

- experience of physical strain in patient transport tasks
- muscular activity in different phases of patient transport
- work postures in different phases of patient transport
- experiences regarding usability

3. Material

3.1. Subjects

The study examined ten paramedics (Table 1), i.e. five working pairs. One of the selection criteria was that each of the stretcher models included in the study was to have been used by one of the pairs in their work.

The test subjects took part in the study voluntarily and gave their signed consent for the processing and utilisation of the research data. In the examination of the subjects' current health, three persons (1 female, 2 males) indicated having musculoskeletal disorders. The symptoms occurred in the hip-lumbar region and in the neck-shoulder region. The problems had not prevented the affected persons from gainful employment within the previous 12 months.

Table 1. The gender, height, weight and work experience of the test subjects. The table lists averages and ranges of variation.

	Age	**Height**	**Weight**	**Experience in paramedic work**
Male (n=6)	34 years (30 - 43)	178 cm (171 - 183)	87 kg (76 - 100)	5.5 years (1 - 9)
Female (n=4)	32 years (29 - 34)	166 cm (158 - 172)	71 kg (54 - 80)	5.5 years (0 - 9)

3.2. Tested stretchers

The test examined three stretcher models: Ferno, Pensi 2000MA and Stryker M1. The essential physical properties of the stretchers are listed in Table 2.

Table 2. The physical properties of the tested stretchers

Pensi 2000MA	Ferno	Stryker M1
Weight 32 kg - composite frame and bed	Weight 48.5 kg - bed 25 kg - frame 23.5 kg	Weight 50 kg - bed 24 kg - frame 26 kg
- Height 20 cm	- Height 23 cm	- Height 18 cm
- Length 190 cm	- Length 193 cm	- Length 197 cm
- Width 55 cm	- Width 58 cm	- Width 56 cm
- Weight limit 200 kg	- Weight limit 181 kg	- Weight limit 228 kg

In the test task, the stretchers were loaded into a van with a stretcher base and attachment arrangements corresponding to an ambulance. The rear compartment had been installed with the required loading ramps at the height normally used in ambulances (Figure 1). The Pensi model utilised the Ergomy® loading aid.

Figure 1. The stretchers included in the study: a) Stryker b) Pensi c) Ferno. The van with the required loading ramps installed can be seen in the background. d) Ergomy loading aid for the Pensi stretcher, e) loading ramp for the Ferno and Stryker stretchers.

4. Methods

4.1. Work simulation

The study was conducted in Sastamala, Finland, between 18 and 19 May 2011. The stretchers were compared in a simulated and standardised work task, where the working pair was to use each stretcher to move a dummy weighing 75 kg from the second floor of a block of flats into a vehicle outside. Each pair was asked to perform the work simulation four times with each transport method. The task was to be conducted in such a way that each member of the working pair would carry the stretcher twice at the feet end and twice at the head end. The order of the transport methods was randomly selected for each pair. The positioning of the paramedics at the foot or head end of the stretcher was similarly randomised.

At the beginning of the task, the stretcher was placed on a landing on the second floor. The 75 kg dummy was in position on the stretcher ready for transport. The task began when the working pair lifted the stretcher off the floor and started moving. The task ended when the stretcher was inside the vehicle. On one occasion for each stretcher model, the pair was asked to move the dummy from the floor of an adjacent balcony onto the stretcher and prepare it for transport.

According to the plan, each pair was to complete 12 simulations. However, during the study it was noted that the task was extremely strenuous; therefore the target was reduced to six simulations per pair. This meant that each person in a working pair would carry each respective stretcher once from the head end and once from the feet end.

One working pair completed nine simulations, two pairs completed six and one pair completed four. A total of 25 simulated work tasks were completed.

4.2. Perceived physical exertion - RPE

The physical strain experienced by the test subjects in the work simulations was examined by means of a subjective RPE (Rating of Perceived Exertion) questionnaire (Borg 1970, Borg 1982). Immediately after the task, the pair answered the question "*How does the level of exertion feel right now?*". The responses were given based on the 15-step Borg scale which begins at 6 and ends at 20. The scale includes expressions describing the level of exertion in order to facilitate selecting the appropriate rating. When answering the questions, the test subjects had a scale printed on an A4 sheet for reference (Figure 2). The scale has been found to correlate with physical activity and heart rate (Borg 1990).

How does the level of exertion feel right now?

6
7 extremely light
8
9 very light
10
11 light
12
13 somewhat hard
14
15 hard (heavy)
16
17 very hard
18
19 extremely hard
20

Figure 2. The Borg RPE scale.

4.3. Electrical activity of muscles - EMG

The required muscle exertion and the load on the musculoskeletal system when using each of the stretchers for the work simulation was studied by means of measuring the electromyography (EMG). The measurements were conducted symmetrically from the right and left side of the body: upper limb, shoulder, upper and low back, and thigh. The measurements were performed with surface electrodes (Ag/AgCl electrodes, M-00-S, Blue Sensor, Medicotest, Ølstykke, Denmark) using bipolar electrode placement, where the distance between the measurement electrodes was approximately 2 cm. The centre point between the electrodes was positioned according to recommendations of Zipp, 1982 and Hermens et al., 1999, with the exception of the electrodes on the forearm for which the electrode placement suggested by Toivonen et al. (1997) was used.

The electrodes were set up on twelve measurement channels as follows:

- ch1, ch5 "Through the forearm" -setting. An electrode pair was placed over the extensor and flexor muscles of the forearm. The measurement tracked exertion in the forearm and wrist area, for example grip force.
- ch2, ch6 Biceps (m. biceps brachii) (ground electrode: on the outer or inner epicondyle of the forearm)
- ch3, ch7 Upper part of the trapezius (m. trapezius pars descendes) (ground electrode: T4 vertebra)
- ch4, ch8 Upper back (rector spinae longissumus Th 10)
- ch9, ch11 Low back (Erector spinae longissumus L1)
- ch10, ch12 Front section of the thigh (Quadriceps Femoris muscle - rectus femoris)

The signals were recorded as averages at a measurement frequency of 10 Hz by means of ME6000 equipment (Mega Elektroniikka Oy, Kuopio, Finland). All work simulations were videoed so that the measured data could later be compared with the simulated work efforts.

In the analysis, the EMG measurements for each stretcher model were separated from the rest. The analysis covered the work simulation from the point that the working pair began moving the stretcher from the second floor (lifting the stretcher off the floor) to the point when the stretcher was inside the ambulance. Based on the signals recorded from the test subjects, average muscle activity levels were calculated for each stretcher model and measurement channel. Finally, the muscle activity levels measured from all test subjects for the three stretcher models were compared at the level of single measurement channels.

Measurement calibration

In the study, maximal activity levels (MVC levels, maximal reference voluntary contraction) determined at the beginning of the measurement cycle were used as reference levels for electrical muscle activity. After the attachment of the electrodes before the work simulations were commenced, the test subjects performed a set of guided test movements (Konrad, P., 2005), during which the maximum muscle activity levels were registered. The test movement (Figure 3) was repeated twice for each muscle group, with approximately 30 seconds of rest between repetitions. All test movements were static (isometric). In the test that activated the forearm, biceps, trapezius and thigh, the movement of the limb or body part was restricted with a tightened strap (Figures 3a-c). In the forearm test, the test subject was asked to pull the tightened strap by bending his or her wrist. The test was carried out in two ways, with the palm up and the palm down. In this way, the extensors and flexors of the wrist could be activated separately. The biceps test movement was performed with nearly the same arrangement, but the subject's forearm was not in contact with the bed, the elbow served as the supporting point and the person pulled the strap up while keeping the wrist straight.

In the shoulder muscle test movement, the subject was asked to lift his or her shoulders as high as possible with straps attached to the bottom of the chair restricting the movement (Figure 3b).

In the test that activated the low back muscles, the subject attempted to extend his or her upper and lower limbs upwards in a diagonal movement as far as possible (Figure 3d).

Figure 3. Calibration movements related to the electromyographic measurement, the purpose of which was to achieve maximal activation of the affected muscle group. a) Biceps and forearm b) Trapezius muscles c) Thigh (ankle attached to the chair leg with a strap) d) Low back muscles.

During the movements, the highest signal values for each channel were recorded and used as each respective subject's reference level for electrical muscle activity in the analysis. In the analysis, electrical muscle activity was processed as percentages from the reference level during initial calibration (%MVC).

4.4. Observation of work postures - REBA

Work postures were assessed with an REBA (Rapid Entire Body Assessment, Hignett, S., & McAtamney, L. (2000)) position examination, which was conducted based on a video recording. In the REBA method, the most straining work posture is first selected by using the position criteria provided by the model. Criteria are available for the neck, lower limbs, body, upper arms, forearms and wrists. In addition, the method takes into account muscle exertion (for example, lifting) and the quality of the grip enabled by the item/equipment being handled. The exposure caused by the posture is indicated with a number on a scale of 1 to 15. Number 1 means that the risk of exposure caused by the work posture is negligible, whereas number 15 indicates that the risk of exposure is extremely high.

In the analysis phase, the work task (moving the dummy on a stretcher from the second floor into the vehicle outside) was divided into four separate work phases. The effect of the examined stretchers on the work postures of the paramedics was assessed during lifting, carrying, installation of auxiliary equipment and loading.

4.5. Usability questionnaire

Approximately one month after the tests, a letter containing a usability questionnaire (Appendix 1) was delivered to the home addresses of the test subjects. The questionnaire aimed to determine the perceptions of the subjects on the usability of the stretchers in various situations of use (VAS scale) and on the general usability of the products (SUS questionnaire). In addition, the questionnaire requested the subjects to rank the stretchers with regard to the requirements of the test situation.

The evaluation related to the situations of use was recorded on a 100 mm line called a VAS scale. The situations to be assessed were 1) lifting off the ground, 2) stairway navigation, 3) landing navigation, 4) outdoor stair navigation and 5) loading into the vehicle. The person entered a vertical line on the scale at the location that best described the experience. The left end of the scale represents the evaluation “very poor” while the right end represents the evaluation “very good”.

Experiences of the overall usability of the patient transport methods were obtained by means of a subjective SUS survey (System Usability Scale) (Brooke 1996). The ten-point questionnaire provides an overview of the usability of a product, as experienced by the test subjects. The range of the SUS points is 0 to 100. A score of over 80 indicates that the product’s usability is good (grade A), where as a score lower than 51 is an indication of poor usability (grade F).

4.6. Statistical analysis

The statistical analysis of the data was conducted entirely by means of R software (R Development Core Team (2008)). Non-parametric methods were used in the statistical analyses. The Wilcoxon signed-rank test was used in the comparison of pairs of ordinal scale variables.

5. Results

5.1. RPE assessment

After transporting the stretcher and the dummy into the vehicle, each working pair stated their current level of exertion on a 15-point RPE scale. A total of 20 values were collected for each stretcher model.

The distributions of the RPE evaluations are presented in Figure 4. The RPE values recorded for the Pensi stretcher are significantly lower than those recorded for the Ferno and Stryker stretchers. No difference was found between the Ferno and Stryker stretchers in terms of perceived exertion.

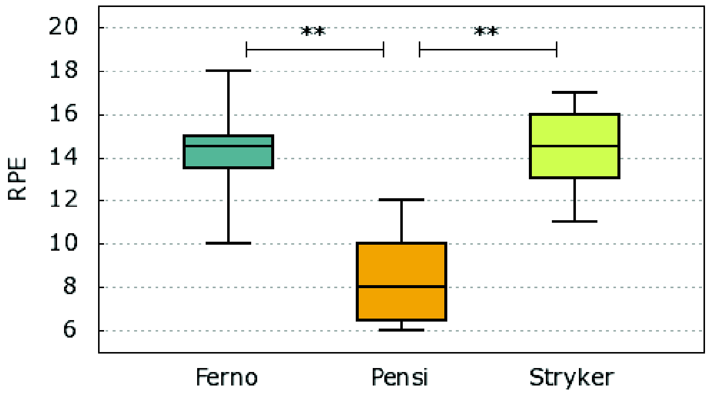

*Figure 4. Distributions of the RPE evalutions by stretcher type. The line in the centre of the box represents the median of the responses, the upper and lower edges of the box indicate the first and third quartile, and the horizontal lines represent the minimum and maximum values of the responses. In the figure, statistically significant differences (Wilcoxon) between the stretchers are indicated with ** (p < 0.01)*

5.2. EMG - Electrical activity of muscles

As regards the results of the EMG measurements, the average activity levels for each measurement channel were compared. The phases in the work simulations where the dummy was lifted from the balcony floor onto a stretcher were not included in the analysis.

Figures 5 to 7 present the average electrical muscle activity levels calculated for the entire test group, separated according to measurement channel and stretcher type. It is evident that, with the Pensi stretcher, activity was lower in ten measurement channels compared to the Ferno stretcher. In comparison to the Stryker stretcher, activity was significantly lower in eight channels, particularly the back muscles. Significant differences were not found between the Ferno and Stryker stretchers in terms of electrical muscle activity.

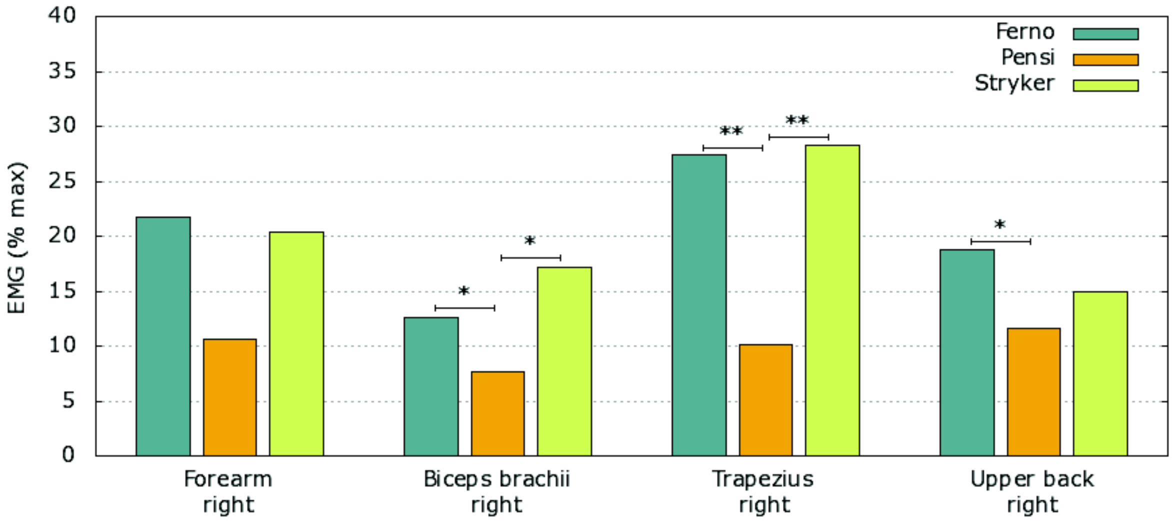

*Figure 5. Averages of electrical muscle activity from the right side of the body. All work phases involved in moving the stretcher were included in the calculation of averages. In the figure, statistically significant differences (Wilcoxon) between the stretchers are indicated with * (p < 0.01)*

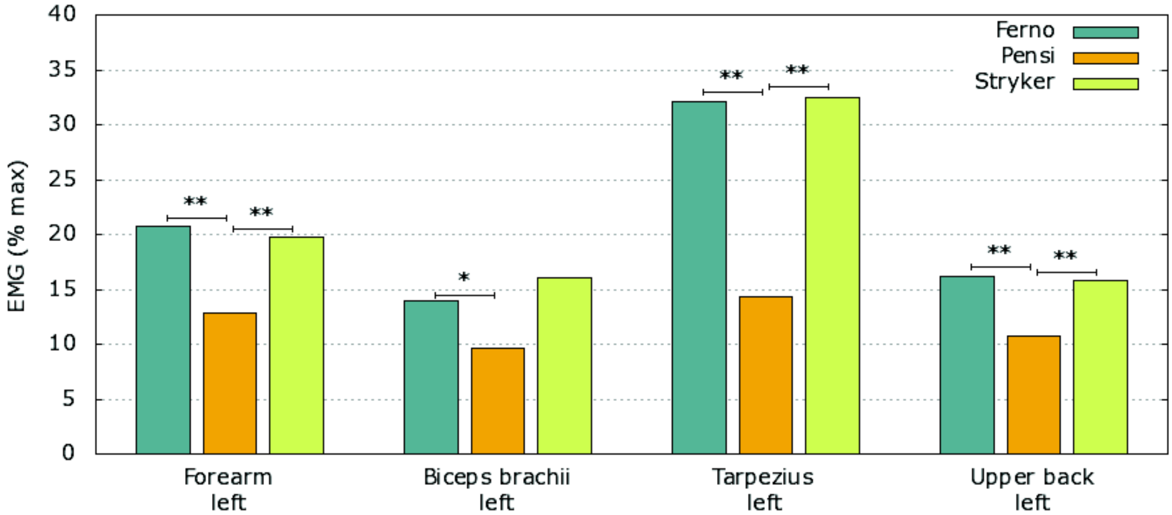

*Figure 6. Averages of electrical muscle activity from the left side of the body. All work phases involved in moving the stretcher were included in the calculation of averages. In the figure, statistically significant differences (Wilcoxon) between the stretchers are indicated with * (p < 0.01)*

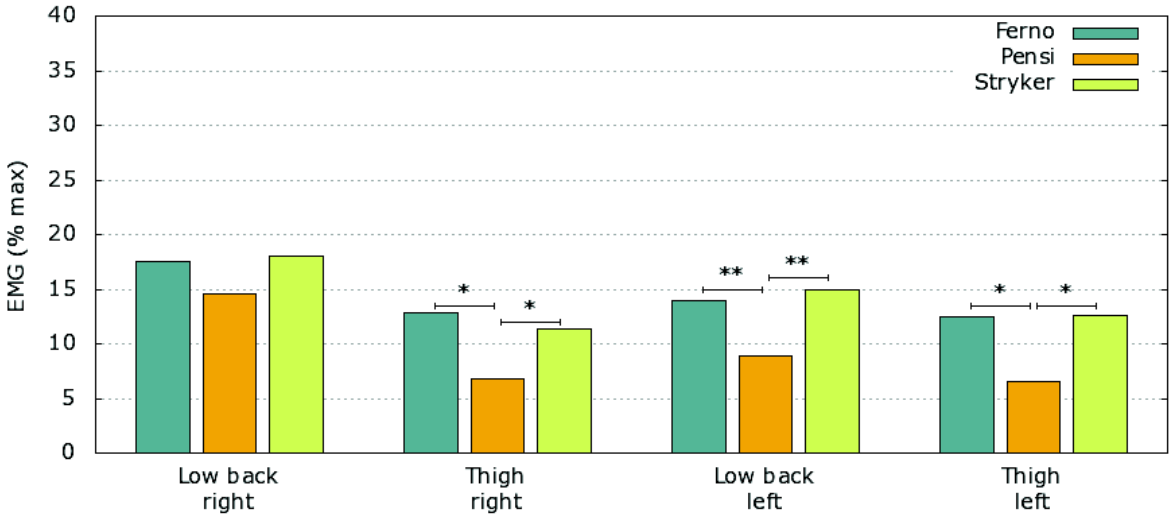

*Figure 7. Averages of electrical muscle activity from the lower body. All work phases involved in moving the stretcher were included in the calculation of averages. In the figure, statistically significant differences (Wilcoxon) between the stretchers are indicated with * (p < 0.01)*

5.3. Work posture analyses

The REBA method was utilised to observe the most stressful working posture in the test task assigned to the paramedics. A total of 141 observations were made of the postures of six separate paramedics during ten transport tasks. When evaluated with the REBA method, the physical load caused by working postures with the Pensi stretcher was found to differ significantly from the load recorded for the Ferno and Stryker stretchers.

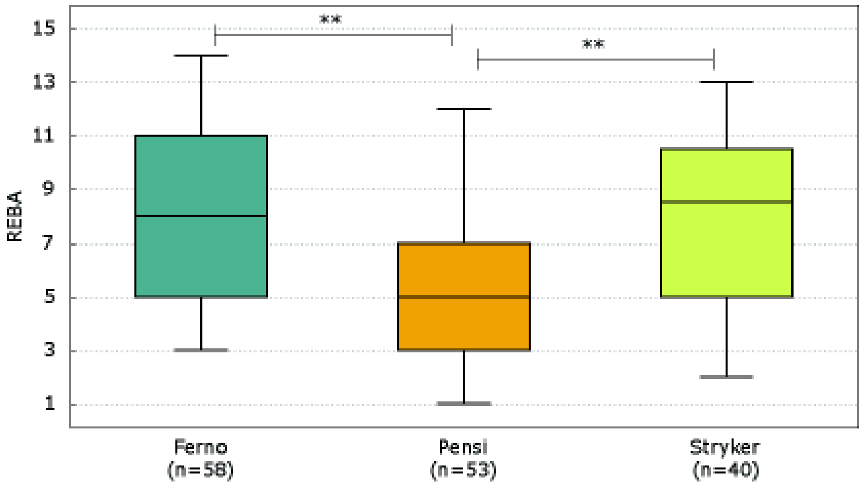

*Figure 8. Distributions of working posture observations (REBA) when using three separate stretchers. The line in the centre of the box represents the median of the responses, the upper and lower edges of the box indicate the first and third quartile, and the horizontal lines indicate the minimum and maximum values of the responses. The REBA scale ranges from 1 to 15. A lower score indicates lower load caused by the working posture. In the figure, statistically significant differences (Wilcoxon) between the stretchers are indicated with ** (p < 0.01)*

Lifting off the ground

The patient transport stretcher affected the paramedics' working posture when it was lifted off the ground to a carrying position (Ferno/Stryker) or to rest on the legs of the stretcher (Pensi) (Figure 9). Over longer transport distances, the Ferno and Stryker stretchers required more frequent lifting off the ground than the Pensi stretcher. The stops resulted from the carrying paramedics becoming fatigued or losing their grip.

Figure 9. Typical work postures when lifting the different stretchers off the ground.

Factors that affected the working posture during lifting were each stretcher's position in relation to the paramedic, the weight of the stretcher, the number of persons in the lifting situation or the methods required by the stretcher.

Ferno or Stryker

- The stretcher was either behind or in front of the paramedic's body
- Both paramedics were required to lift as a wheel-mounted frame was not included
- The weight of the stretcher, as the paramedics were required to lift it without assistance

- The cooperation between the paramedics and their control of their own body and balance, as the carriers needed to lift the stretcher simultaneously

Pensi

- The stretcher was positioned in front of the paramedic's body
- Only one of the paramedics was required to lift the stretcher as the frame is foldable and integrated into the bed
- The stretcher was raised onto its own legs, which allowed the other paramedic to assist in the lifting

Carrying

In the work task, the stretcher was transferred on even asphalt and on stairs (Figure 10, a series of images illustrating the different phases of the carrying process). In transferring, the work postures were affected by the stretcher's position in relation to the paramedic, the stretcher's weight and whether or not a stair cylinder was used. In narrow spaces in particular, the Ferno and Stryker models required room to turn, whereas the Pensi stretcher could be raised into an upright position where necessary. Lifting the Pensi stretcher into an upright position or using the stair cylinder on the stairs caused the paramedics to experience upper limb positions that, according to the REBA method, increased strain. The Pensi stair cylinder reduced the physical effort required of the paramedics, but the wheels presented problems when obstacles (for example, doorsteps) were encountered.

Figure 10. A series of images on the carrying process with different stretchers.

Installation of auxiliary equipment

The bed of the Ferno and Stryker stretchers needed to be placed on a wheel-mounted transport frame (Figure 11a), whereas the frame of the Pensi model was attached to the bed at all times. Aligning the bed with the transport frame is difficult due to poor visibility. As a result, the paramedics are required to bend over to look under the bed while lifting it onto the frame. The handles that attach the bed to the frame are located near the transport handles. If a paramedic did not have an adequate understanding of working with the handles, the phase could take an unreasonable amount of time and cause strain for the person.

A stair cylinder was installed on the Pensi stretcher, which was an additional work phase in comparison to the Ferno and Stryker models (Figures 11a and 11b). Installation of the cylinder required the paramedics to lower themselves on one knee or crouch (Figure 11c).

Figure 11. a) Installing the transport frame on the Stryker and b) Ferno. c) Installing the stair cylinder on the Pensi stretcher.

Loading

With the Pensi stretcher, the loading phase was electrically assisted, whereas the Ferno and Stryker models were slid into the vehicle along a loading ramp (Figure 12). The Ferno and Stryker stretchers require the paramedics to be precise in aligning the stretcher with the ramp and to be adept at using the handles to release the transport frame mechanism. During the loading phase, the paramedics had to lift the foot of the stretcher in order to slide the assembly along the ramp. This caused strain on the shoulders. The essential phases in the loading of the Pensi model were releasing the wheel locks and attaching the bed to the lifting device for loading.

Figure 12. Loading the stretchers into the vehicle. a) Loading of the Pensi model is assisted by the Ergomy mechanism. b) The Ferno and Stryker models must be slid in along the loading ramp by lifting the foot of the stretcher.

5.4. Usability questionnaire

Seven completed questionnaire forms were returned for study. Five of the respondents stated that they use a Pensi stretcher in their work regularly. One indicated that they used a Pensi stretcher fairly often while one had used a Pensi model infrequently. Three respondents reported using a Ferno stretcher in their work on a regular basis, while one person stated having used a Ferno model on rare occasions. One of the respondents used a Stryker model regularly, while one had used a Styker on a number of occasions.

One of the respondents had used a stair cylinder on an infrequent basis. Two persons had used an Ergomy loading aid previously; one of these persons used the system regularly.

The respondents assessed the benefit of the stair cylinder and Ergomy loading aid in their work on a scale of 1 to 5 (1 = no benefit at all, 5 = extremely beneficial). The average of the answers was 3.3 for the stair cylinder and 3.1 for the loading aid. In other words, the respondents felt that the devices were moderately useful or very useful.

The following statements were given as justifications for the answers:

- “One of Pensi’s definite benefits is its lightness.”
- “Both facilitate the lifting process, particularly if you use the stretcher regularly and by yourself. Your partners’ hands are freed for ventilation, for example. However, if a patient is, for instance, ventilated on site, there are normally more units present.”
- “The area where I work contains very few blocks of flats, so I probably wouldn’t install the cylinder for a few steps. The Ergomy would be useful to assist loading.”
- “I don’t use the stair cylinder on a daily basis because buildings normally have lifts and you can use a carrying chair. However, I use the Ergomy system all the time. It takes some getting used to.”
- “Places practically no stress at all on your back or legs. The loading phase becomes considerably easier in particular.”
- “The stair cylinder considerably reduces the carrying load. The loading aid also assists in moving the patient into the vehicle.”

Usability of the stretchers in different work phases (VAS evaluation)

The respondents were asked to evaluate the usability of the products in the various phases of patient transport. The evaluations were separately entered on a VAS scale for each situation and stretcher.

The distributions of the responses (n=7) are presented in Figure 13. In four of the five assessed situations, the Pensi stretcher was evaluated to be significantly better than the Ferno or Stryker models in terms of usability. With regard to lifting off the ground, a statistically notable difference formed between the Pensi and Stryker models.

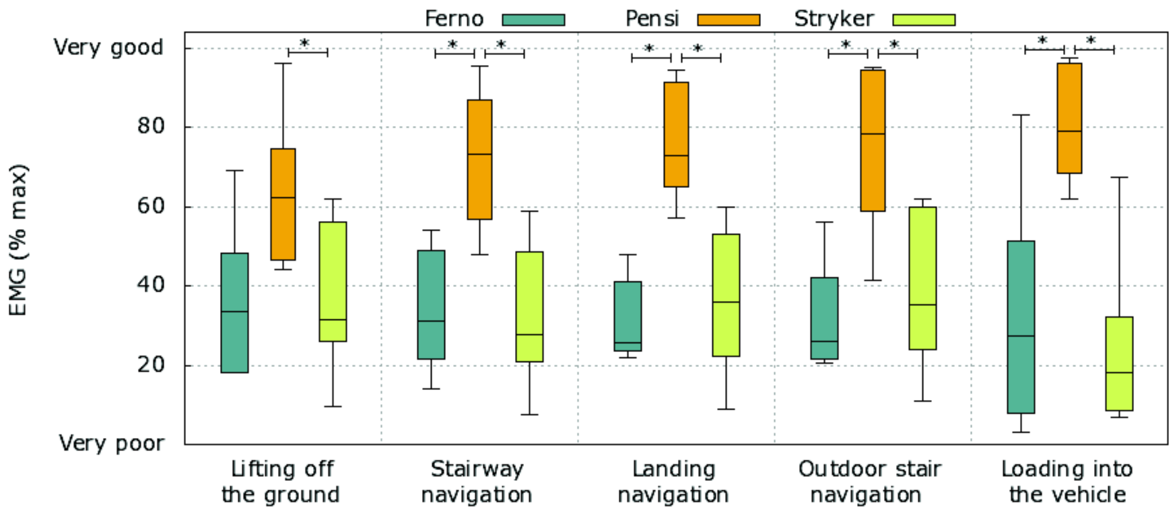

*Figure 13. VAS evaluations (n=7) on stretcher usability in different phases of the patient transport. The line in the centre of the box represents the median of the responses, the upper and lower edges of the box indicate the first and third quartile, and the horizontal lines indicate the minimum and maximum values of the responses. In the figure, statistically significant differences (Wilcoxon) between the stretchers are indicated with ** (p < 0.05)*

Stretcher usability evaluated with the SUS method

In the SUS evaluation, a marked difference was found between the Pensi and Stryker models (Figure 14).

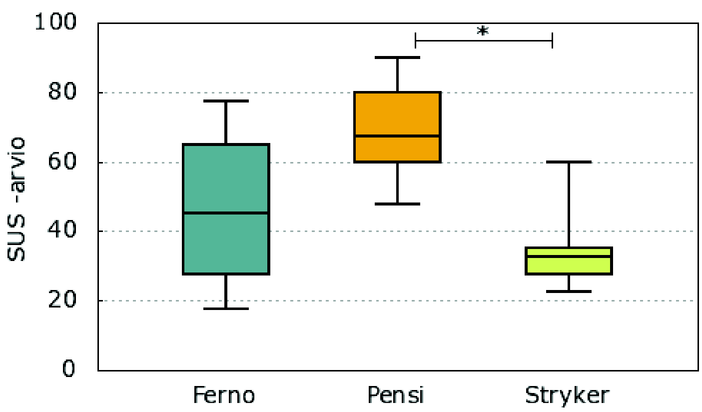

*Figure 14. Distributions of the SUS evalutions by stretcher type. In the figure, statistically significant differences (Wilcoxon) between the stretchers are indicated with ** (p < 0.05)*

The averages of the stretcher evaluations were as follows: Ferno = 45.0, Pensi = 68.9 and Stryker = 34.3. In terms of grades on a scale from A (best) to F (worst), the usability of the Pensi stretcher was rated C, whereas the Ferno and Stryker models were rated F.

Ranking

At the end of the questionnaire, the respondents were asked to rank the stretchers from best to worst (1st, 2nd and 3rd) with regard to the test situation. The stretcher that felt the best in the test situation was to be ranked first, while the one that felt the worst was to be ranked third.

All respondents (7) ranked the Pensi stretcher as the best of the three. Stryker received second place from four respondents, and Ferno was selected as the second best model by three people.

5.5. Observations and ideas for product development

- A foldable slide sheet or board under the bed in order to improve the ergonomics of moving a patient off the ground onto the stretcher or off the stretcher onto another platform or bed.
- A foothold in the frame to prevent tipping during lifting and to facilitate restoring the stretcher into the horizontal position (Figure 15a). The foothold would help to push the stretcher forward in the horizontal position and lessen the load on the paramedics hands when the stretcher is lowered into the horizontal position.
- Currently, the attachment of the stair cylinder requires precise alignment and squeezing with the index finger and thumb → solution?
- Visibility stickers and colour codes on the handles or release buttons.
- The mobility of the wheels when turning in narrow spaces. How would stretcher transport function if the wheels at the foot end or on the stair cylinder rotated?
- Are the size (for example, diameter) and hardness of the small wheels at the front of the stretcher and on the stair cylinder optimal for the purpose?
- The shape and comfort of the handles.
- The positioning or transport of the stair cylinder when it is not in use?
- The noise made by the stair cylinder.
- Training demands:
  - Use of the Pensi 2000MA stretcher: how to change the position of the bed, how to adjust the handles, what is the optimal position of upper limbs when using the stair cylinder.
  - Efficient cooperation between the pairs and the correct work postures (for example, lifting the stretcher to an upright position (Figure 15a), adjusting the leg section when preparing the stretcher for transport (Figure 15b)).
  - Avoiding raised arm postures when the stretcher is in an upright position (Figure 15c-d).
  - Mounting doorsteps smoothly (Figure 15e).

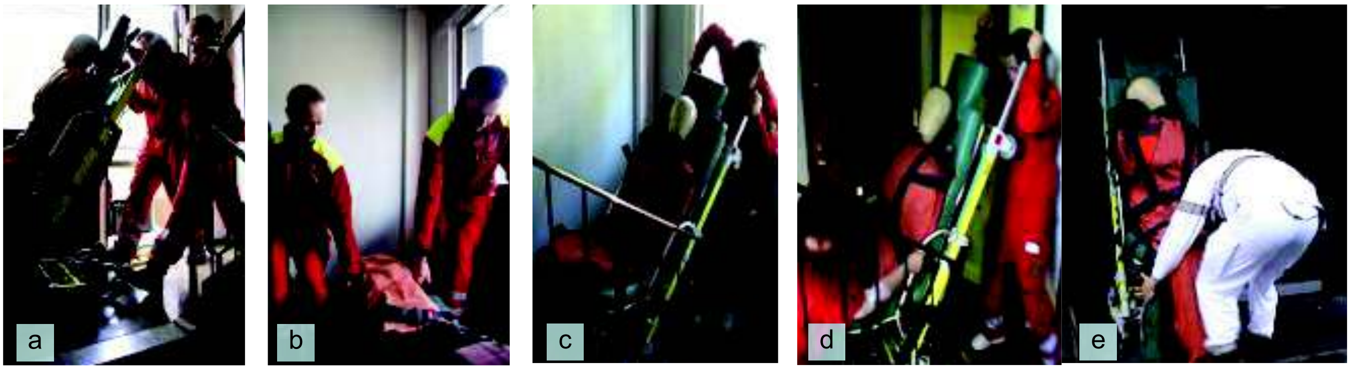

Figure 15. Images of the usage situations of the Pensi stretcher. a) Lifting the stretcher into an upright position. b) Raising the leg section. c-d) Difficult upper limb positions on the landing. e) Mounting a doorstep.

6. Summary, conclusions and considerations

The study showed that stretcher type has an impact on the physical workload and ergonomics of paramedics. The Pensi stretcher reduced the paramedics' experience of physical load and low back muscle activation while increasing the ergonomics of the work postures in comparison to the Ferno and Stryker stretchers. In addition, the paramedics found the Pensi stretcher to be more comfortable to use than the other models, particularly during transferring and loading. It should also be noted that the Ferno and Stryker stretchers included in the study are models commonly used in patient transport. Therefore, they do not necessarily represent the latest stretcher models of their manufacturers.

According to the study, the Pensi stretcher can reduce workload and increase occupational safety among paramedics as the stretcher reduced the physical load factors of the work. Additional research is required on the long-term effects of stretcher types on the physical load factors in the work of paramedics and on the musculoskeletal disorders caused by these factors. A cross-sectional analysis is not suited for this type of research as more prolonged intervention studies are required.

The use of the Pensi stretcher differs from the Ferno and Stryker models, as the fixed frame enables transport on wheels instead of carrying. On stairs and during loading in particular, the use of the Pensi stretcher differed from the use of traditional stretchers. Therefore, the usage training of the Pensi stretchers must clearly introduce the functions of the stretcher, and each paramedic must practice using the stretcher in different environments before engaging in patient handling and transferring tasks. Furthermore, the maintenance of all stretcher models must be properly conducted in order to ensure that they can be used smoothly and correctly.

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