Abstract: Paramedics perform physically demanding tasks during patient transport in daily routine and therefore suffer more often from musculoskeletal ailments, mainly low back pain, than any other profession. We hypothesise, that current transport aids do not offer sufficient support when it comes to obstacles and stairs during patient transport. Therefore we conducted an Ovako Working Posture Analysing System (OWAS) field study to capture postural workloads during patient transport and connected the results to a survey among paramedics about occurring obstacles. The results of the OWAS analysis showed strenuous working conditions during barrier-free transport with classical transport aids, like stretcher and stretcher chair, but enormous postural workloads when barriers occurred. Our survey revealed, that stairs occurred in 38 %, and at least one barrier, like narrow passages, curbs, etc., in 48.1 % of all deployments (n=405), we can quantitatively link postural workloads with occurring obstacles. In conclusion, there is a high demand for ergonomic improvements of current transport aids and a high potential of active assist devices to reduce harmful loads on paramedics.

Keywords: Biomechanics, Paramedics, Patient transport, OWAS, Transport aids, EMS.

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1 Introduction

About 12 million deployments are carried out by the providers of emergency medical services (EMS) in Germany annually with rising tendency [1]. During these deployments main tasks of the paramedics are to provide acute-medical service and safe transportation.

For paramedics transportation is a physically demanding task with severe impact on their health. Several studies show that work induced injuries in EMS occur more often [2], [3] and early retirement rates are the highest compared to any other industry [4]–[6]. Since women in EMS are more likely to suffer from injuries than men [4], [7] and a rising number of women are employed in this sector [8], rising injury rates can be expected. In comparison to other medical professions, such as nursing, the risk to suffer from injuries is 13 times higher [9]. Musculoskeletal disorders are most prevalent among paramedics. Especially back pain is the major problem [9], [10], which is directly associated with high cumulative loads on the back [11]. These loads on the upper and lower back are caused by the frequent lifting and carrying of patients [12], [13] and are aggravated by working in harmful postures [14]. These facts indicate that transportation is the major cause for this problem and ergonomic improvements of transport aids are a key factor to improve the current situation.

Actually, most common transport aids are the main stretcher, increasingly used with hydraulic height adjustment and the stretcher chair (carry chair). Additional tools, such as soft stretcher, spine board and scoop stretcher are available for special conditions, where the favoured aids are inaccessible or the patient needs special treatment. Powered devices actively assisting the paramedics are more and more available but rarely used in the daily EMS routine, mainly because they are too slow, too bulky or not suitable for general use. For an effective integration of such devices into EMS further developments and ergonomic improvements are required [15]. Consequently, when it comes to obstacles, paramedics still have to manually carry the patient including the transport aid and thereby regularly exceed the physiologically recommended work load of 10 kg for women and 30 kg for men [16], leading to unphysiological stresses and injuries.

Whereas, the relationship between injuries and working conditions in EMS is well analysed, quantitative data on relevant obstacles and their impact on postural workloads is lacking. For this reason the goal of our study was to quantitatively analyse the occurrence of different obstacles
during patient transport and combine this information with a postural workload analysis during daily routine of paramedics.

2 Material and Methods

The analysis has been conducted in cooperation with the emergency medical service of the Düren district (Rettungsdienst Kreis Düren), Germany, in July 2017. This provider has 12 stations with 23 ambulance vehicles in total and is responsible for approximately 260,000 inhabitants, living in rural areas (66.4 inhabitants/km²) as well as in urban areas (1050.7 inhabitants/km²).

In this context a special screening [17] using a questionnaire was designed. In a period of two weeks each ambulance team was asked to fill out a questionnaire in each shift giving data about each deployment. The queried data consists of:

- the occurrence of stairs including details about direction (up/down) and number of stories and
- the occurrence of the obstacles: curbs, narrow places, stumbling blocks, difficult floor coverings (carpets, sensitive floors, etc.) and difficult ground (gravel, sand, etc.).

To gather data about the subjective behaviour of the paramedics during a deployment an expert screening based on an OWAS analysis [18], [19] was performed by an uninvolved expert, who observed and classified the postures of the paramedics at a constant frequency of approximately 30 seconds. The assessment was carried out at day shifts during five consecutive days by accompanying the paramedics during their deployments (emergency and non-emergency) without interfering with the situation. The acquisition starts with the loading of the patient and ends once the patient arrives at the ambulance or deployment site. Working postures of back, arms and legs as well as the load effort are monitored directly onsite by pen and paper. The OWAS classification matrix includes four postures for the back, three different postures for the arms and seven different postures for the legs. In addition, there are three intervals for the estimated load (<10 kg, <20 kg, >20 kg). For each posture-load combination, the resulting risk is classified and colour coded:

- Green: Normal posture, no intervention necessary
- Yellow: Slightly harmful, corrective action should be taken into account soon
- Orange: Distinctly harmful, corrective action should be taken as soon as possible
- Red: Extremely harmful, corrective action should be taken immediately.

3 Results

3.1 Survey

We received 150 questionnaires providing data on the occurrence of stairs and obstacles in 405 deployments (Table 1).

Table 1: Occurrence of Stairs and Obstacles during 405 EMS deployments.

<table>
<thead>
<tr>
<th>Absolute deployments</th>
<th>Relative Occurrence (n=405)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stairs</td>
<td></td>
</tr>
<tr>
<td>down, 1 floor</td>
<td>84</td>
</tr>
<tr>
<td>down, 2 floors</td>
<td>26</td>
</tr>
<tr>
<td>down, 3 floors</td>
<td>7</td>
</tr>
<tr>
<td>down, &gt;3 floors</td>
<td>3</td>
</tr>
<tr>
<td>up, 1 floor</td>
<td>23</td>
</tr>
<tr>
<td>up, 2 floors</td>
<td>6</td>
</tr>
<tr>
<td>up, 3 floors</td>
<td>4</td>
</tr>
<tr>
<td>up, &gt;3 floors</td>
<td>1</td>
</tr>
<tr>
<td>No obstacles</td>
<td>210</td>
</tr>
<tr>
<td>Narrow passages</td>
<td>116</td>
</tr>
<tr>
<td>Curbs</td>
<td>92</td>
</tr>
<tr>
<td>Difficult floor covering</td>
<td>74</td>
</tr>
<tr>
<td>Stumbling blocks</td>
<td>57</td>
</tr>
<tr>
<td>Difficult floor surfaces</td>
<td>53</td>
</tr>
</tbody>
</table>

The data shows with an occurrence of 38% that stairs are a common problem in EMS. Since the usual mission is to transport the patient to medical care facilities, which are barrier-free, the patient is more often transported downstairs than upstairs. Next to stairs other obstacles occurred in 48.1% of the deployments. Most often narrow passages (28.6%) and curbs (22.7%) were reported.

3.2 OWAS Field study

The OWAS field study delivered data on the working postures of paramedics in 17 deployments. The mean distribution and two deployments including stairs are shown in figure 1.
4 Discussion

In this study a questionnaire and an OWAS field study was used to analyse dynamic working conditions in EMS and resulting health risks for paramedics. The results show a correlation between the well-known fact of work induced low back pain among paramedics [9], [10] and the occurrence of obstacles in the daily EMS routine. This information is important for the design of more suitable ergonomic transport aids.

The typical patient transport with a stretcher showed a low health risk for ground level transport, which is consistent with literature [20]. However, our study shows as well that stairs (38 %) and obstacles (48.1 %), preventing an ergonomic use of the stretcher, occur quite often. In these cases the paramedics have to lift or carry the stretcher in order to continue, resulting in high postural workloads and associated potentially severe health risks.

The OWAS results during straight stair transport using the stair chair already showed a higher risk in comparison to ground level transport. The OWAS method defines its maximum load level at 20 kg, but in the observed cases substantially higher loads occurred. As an estimate, two paramedics have to carry the weight of the patient (> ~60-100 kg) and the carry chair (~17 kg), easily leading to loads above 40-60 kg for each paramedic, which is way more than the suggested 30 kg [16]. Therefore, we believe, that the results of our OWAS analysis rather underestimate the resulting health risks for paramedics. Lavender et al. [21] confirm this suggestion. They showed that during chair transports extreme loads on the spine occur and patient weight of only 48 kg leads to loads which only 82% of the population has the adequate back strength to perform.

Curved stairs lead to extreme problems during transport. Asymmetric working postures combined with high loads lead to an extreme risk, mainly caused by constrained workspace. Such restrictions are generally known to lead to unphysiological postures and a laboratory study which simulated a 90° turn on a landing using a stair chair confirmed this principle [21] even though their stair setup was wider than in typical buildings [20]. Therefore negative effects are supposedly worse during real deployments.

Several limitations of our study have to be considered. Firstly, the OWAS analysis captured body postures on the basis of multi-moment observations by one observer. Only two observations were documented per minute. According to the OWAS method, the relative percentage of working posture and posture categories were calculated from these observations. Video or sensor based motion analysis potentially could provide more reliable data based on higher sampling rates. However, our OWAS analysis confirmed other comparable studies and therefore valid results can be assumed. Furthermore, a relatively modest number of deployments was captured, but our numbers are in the same range as other studies [20]. A limitation of the survey is that the paramedics themselves gathered the data based on questionnaires. Therefore it needs to be considered that the motivation to fill out the questionnaire could have been
higher when stairs or obstacles occurred. However, the link between the survey data and our OWAS analysis confirm the limitations of actual transport aids especially regarding stairs or other obstacles, even if absolute numbers of occurrence could be subject to further investigations.

Conclusion: To improve working conditions for paramedics, improvements of transport aids with more ergonomic features should be considered. Especially active transport aids may help to reduce postural workloads of paramedics by support of the carry process.

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