Annoyance-rate-and-casualty-reality-based method of comfort evaluation of military ambulance

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Abstract. The objective of this paper is to explore a new comfort evaluation method, which is suitable for studying the comfort of casualty transported by a military ambulance. The paper applies existing vibration evaluation methods to quantitatively obtain comfort of non-ambulatory casualty, stimulates the patients with different vibrational conditions, and analyses the annoyance rates with psychophysics knowledge as well as the ratio of war to disaster injuries and susceptibility of the wounded. The road test proves that this new method is feasible for vibrational comfort evaluation of non-ambulatory casualty and gains quantitative advantages over the traditional methods.…

1. Instruction
The vibration comfort of the lying human body refers to the subjective feeling of the lying person exposed to the vibration environment, which should be controlled within a suitable range to reduce the discomfort of the lying human body. In order to transport the comfort of the injured and sick, the vibration comfort control of the ambulance is required. Compared with civilian ambulances, military ambulances operate in a harsh environment and are subject to vibrational complexity, in order to avoid secondary injuries to the wounded and sick, it is necessary to evaluate the comfort

2. Evaluation of vibration comfort of the current lying body
The main evaluation of the current body of the lying body is mainly based on the GB-T 18368-2001"Evaluation of the body vibration comfort of the body in the posture" 1/3 x the average frequency of the square root acceleration to evaluate the vibration comfort of the lying human body. [1][2][3]

3. The current evaluation of human vibration comfort in the current lying position is not enough for military ambulances
The use environment of military ambulances includes low-grade roads and off-road sections in the field, the situation of vibration of the injured and sick is very complex, and there are some shortcomings in the simple application of the national standard method:
   (1) The standard prescribed method is applicable to the situation of a healthy body in a posture, in order to apply the specific situation of the injured and sick, the need for appropriate improvement.
   (2) The permissible weighted acceleration range given in the evaluation of vibration comfort of the human body in the lie-in position is produced by artificial division according to the experimental results. In fact, due to the uncertainty of people's subjective feelings, the various permissible vibration limits given in the standard itself have some uncertainty.
   (3) Because the above standard method gives a qualitative conclusion in determining the subjective feeling of the human body in determining the degree of comfort, it is not necessarily appropriate to simply use the standard in evaluating some large complex vibration systems.
4. An improved evaluation method for vibration comfort of sleeping wounded and sick

4.1. Weighted factor based on the injury site of the injured and injured

In the above evaluation of lying comfort, the weighting coefficient of the lying body is based on the relevant experimental studies, according to the sensitivity of the parts of the healthy human body to the frequency vibration, and the frequency segments are different. Military ambulances are mainly used in battlefields and military forces involved in large-scale natural disasters, carrying the target skilled on the battlefield and the injured after major disasters. According to the relevant research and actual situation, the sensitivity of the affected parts of the affected areas to vibration is greater than the sensitivity of healthy human parts. This paper refers to the u.s. military in Iraq in the field of combat casualty evacuation situation and Wenchuan earthquake casualty site analysis report, the battlefield situation and natural disaster son and wounded in the scene of the analysis of the wounded and wounded.

4.1.1. In the case of the battlefield

According to the relevant information, the United States Army combat brigade in the Iraq war during the 15 months of the reduction of personnel and injuries, as shown in table 1 below:

| Area of injury     | Examples | Percentage (%) |
|-------------------|----------|----------------|
| Head, Neck        | 181      | 36.2           |
| Thoracic          | 37       | 7.4            |
| Lower body        | 35       | 7              |
| Upper and lower limbs | 247    | 49.4           |
| Total             | 500      | 100            |

According to Table 1 above, the proportion of head and chest injuries in the U.S. military is 43.6%, the hip perimeter and below 31.7%, and the leg injury is 24.7%.[4]

4.1.2. In the case of a major natural disaster

Taking the 2008 Wenchuan earthquake as the research object, the relevant research analyzed the injuries of 1039 inpatients and wounded patients, and the concrete results were shown in the following table 2:

| Area of injury       | Examples | Percentage (%) |
|---------------------|----------|----------------|
| Lower limb          | 339      | 31.0           |
| Cranioencephalic    | 242      | 22.1           |
| Upper limb          | 125      | 11.4           |
| Chest back          | 88       | 8.1            |
| Spine               | 82       | 7.5            |
| Multi-part          | 70       | 6.4            |
| Belly Waist         | 59       | 5.4            |
| Pelvic tint and hips| 54       | 4.9            |
| Jaws                | 30       | 2.7            |
| Neck                | 4        | 0.4            |
| Total               | 1093     | 100            |

According to the location of the injured site in the human body analysis: head and chest injury area of about 33.6%, hip peripheral area of 35.6%, the lower part of the leg 31%. Referring to expert opinions, the proportion of battlefield conditions in ambulance conditions is 70%, the proportion of
large-scale natural disasters is 30%, the comprehensive analysis of military ambulance casualty
comfort assessment of the site weighted as shown in the following table 3:

| Parts                      | Battlefield use (%) | Civil conditions (%) | Comprehensive evaluation (%) |
|----------------------------|---------------------|----------------------|------------------------------|
| Head and chest             | 43.6                | 33.6                 | 40.6                         |
| Around the hip and abdomen | 31.7                | 35.6                 | 31.7                         |
| Leg                       | 24.7                | 31                   | 26.7                         |

4.2. Measurement of vibration comfort based on disturbing rate
At present, most of the literature on human comfort evaluation indicators is based on the methods
prescribed by the national standards above, using fuzzy mathematical theory and function fitting to
quantify vibration comfort. The trouble rate method is not based solely on the basis of fuzzy
mathematics and probability theory, the theoretical basis of this model is the signal detection theory of
psychophysics, and its basic mathematical prototyping value statistics method is itself an experimental
data processing method. This paper refers to the literature and suggests that the trouble rate should be
used as an evaluation index for quantitative vibration comfort. In this paper, the rate of annoyance is
the proportion of people who consider vibration "unacceptable" under this condition. The calculation
is as follows [5][6].

In the case of continuous distribution, the rate of trouble is calculated as:

\[
D(x) = \int_{u_{min}}^{\infty} \frac{1}{\sqrt{2\pi}a} \exp \left( -\frac{-(\ln(u))^2 + 0.5\sigma^2}{2\sigma^2} \right) v(u)du
\]

In: \( u \) is to bear the corresponding vibration acceleration, is not feel vibration acceleration

\[
v(u) = \begin{cases} 1, & u < u_{min} \\ \alpha \ln(u) + b, & u_{min} < u < u_{max} \\ \sigma \ln(u_{max}) + b, & u_{max} \end{cases}
\]

x is calculated to calculate the weighted mean square root acceleration

\[\sigma = \sqrt{\ln(1 + \delta^2)}\] To feel the coefficient of variation of the difference under the feeling; \( \delta \)
a, b is based on the pending coefficient obtained from the experiment. In this paper, according
to table 1 above, to determine the weighted acceleration of the average square root of 2.5m/s², the
vibration strength is "unacceptable" the acceptance ratio of 1, the weighted acceleration is the square
root 0.315m/s², the vibration strength is "unacceptable" the acceptance ratio of 0. Fit according to the
next pair a, b,

\[
\begin{align*}
\alpha \ln(u_{min}) + b &= 0 \\
\alpha \ln(u_{max}) + b &= 1
\end{align*}
\]

The result of the fitting is \( a = 472, b = 0.542 \).

4.3. Comprehensive Vibration Comfort Analysis
In the analysis of vibration comfort of the wounded and sick in military ambulances, it is obviously
inappropriate and incomplete to summarize the overall vibration comfort of the ambulance by simply
the vibration comfort under a certain operating condition. Therefore, on the basis of the relevant
literature, "Research on the evaluation method of automobile comfort", combined with the above
contents, this paper presents the comprehensive vibration comfort distress rate of the lying human
body; in order to solve the different speed, The vibration comfort caused by different factors such as
different road surfaces is difficult to evaluate and compare.

(1) Consider the different proportions of cars driving on different levels of road. According to the
specific type and actual function of the ambulance, according to the use probability and statistics of
the vehicle on different road surfaces to determine the weighted set of the type of road travel, to
determine the vehicle operation of the m road level proportional factor vector:

\[ A_1 = [a_1, a_2, ..., a_m] \]
(2) Consider the difference of vehicle driving speed on the same grade road surface, mainly based on the relative frequency and time used in road test speed, and combined with the driver's skilled experience, to determine the speed weighting coefficient.

\[
A_2 = [b_1, b_2, \ldots, b_n]
\]

(3) According to the above trouble rate calculation formula, determine the m road level under n speed, a total of the trouble rate under the condition, establish a matrix: \(m \times n D_{mn}\)

\[
R = \begin{bmatrix}
d_{11} & d_{12} & \ldots & d_{1n} \\
d_{21} & d_{22} & \ldots & d_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
d_{m1} & d_{m2} & \ldots & d_{mn}
\end{bmatrix}
\]

The overall distress rate was evaluated as:

\[
D = A_1 \cdot R \cdot A_2^T
\]

5. A certain type of military ambulance vibration comfort evaluation

A type of military ambulance is modified by a large civilian bus, which is mainly used to transport the wounded in the field and the mass casualties in large-scale disasters. The vibration comfort evaluation for this type of ambulance is carried out below.

It combines statistical information in the relevant fields and is determined by evaluators such as academic experts and professional drivers on the basis of actual situation and experience. By the team experts determined that a type of military ambulance used road conditions are generally, approximately C-level road on rural roads, similar to B-level road on urban and rural roads, similar to A-level road urban trunk roads, highways. For the convenience of the test, only one optimal speed is maintained at each road level. After the road test, consult professional drivers to determine that in the approximate C-class road, in order to ensure the comfort of the sick and wounded, the bus can maintain 50 km/h speed, in the approximate B-class road, the bus can maintain 70 km/h speed, in the approximate A-class road, the bus can maintain 90 km/h speed, the details as shown in table 4.

| Road level | Road weight (%) | Best speed (km/h) | Speed weight (%) |
|------------|----------------|-------------------|-----------------|
| A          | 40             | 90                | 100             |
| B          | 30             | 70                | 100             |
| C          | 30             | 50                | 100             |

According to the relevant experiments to measure the body in the stretcher position of the vehicle in the above three conditions of the head, hips, legs acceleration curve, into 1/3 octave analysis, get 1/3 octave acceleration as shown in the figure 1 below.

Figure 1 1/3 octave acceleration of human body parts under each operating condition

1) GB_T 18368 1/3 Octave mean square root acceleration analysis
Table 5 analysis method of GB_T 18368-2001

| Road level                  | Weighted acceleration (m/s²) | Comfort                            |
|-----------------------------|------------------------------|------------------------------------|
| Class A road 90km/h        | 0.2230                       | There's no discomfort.             |
| Class B road 70km/h        | 0.5284                       | Slightly uncomfortable / It's uncomfortable. |
| 50km/h of C-class pavement | 1.0423                       | Not feeling well.                  |
| Comprehensive evaluation   | 0.5604                       | Slightly uncomfortable / It's uncomfortable. |

The type of casualty evacuation car in the A-class road to 90km/h driving is not uncomfortable, B-class road 70km/h, between slightly uncomfortable and more uncomfortable, C-class road 50km/h speed feel uncomfortable, using 3.3 in the comprehensive vibration acceleration of each operating condition s0.5604 m/s² The human body feels somewhere between slightly uncomfortable and more uncomfortable [7].

2) Adopt the analysis method proposed in this paper

Table 6 Analysis Method of this article

| Road level                  | Trouble rate              |
|-----------------------------|---------------------------|
| Class A road 90km/h        | 0                         |
| Class B road 70km/h        | 0.196                     |
| 50km/h of C-class pavement | 0.5683                    |
| Comprehensive              | 0.23                      |

The overall vibration distress rate of the type of casualty evacuation vehicle was 0.23, equivalent to only 23% of the personnel will feel uncomfortable.

6. Summary

In this paper, in view of the complex characteristics of the operation of military ambulances, this paper puts forward the deficiency of the evaluation standard of GB-T 18368, and improves it in combination with the actual improvement of the wounded and sick, and makes a quantitative assessment of the vibration comfort of the patients with horizontal conditions by using the disturbing rate evaluation method of improving the area weighting coefficient. And carry out the comprehensive trouble rate under each condition to carry out the vibration comfort evaluation of the overall operation of ambulance. The results show that the analysis method of trouble rate and the national standard evaluation method are consistent and can represent the reaction of the injured and sick to vibration in proportion, and realize the quantification of the evaluation results, so that the vibration comfort evaluation of the casualty car is more accurate and has certain reference significance.

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