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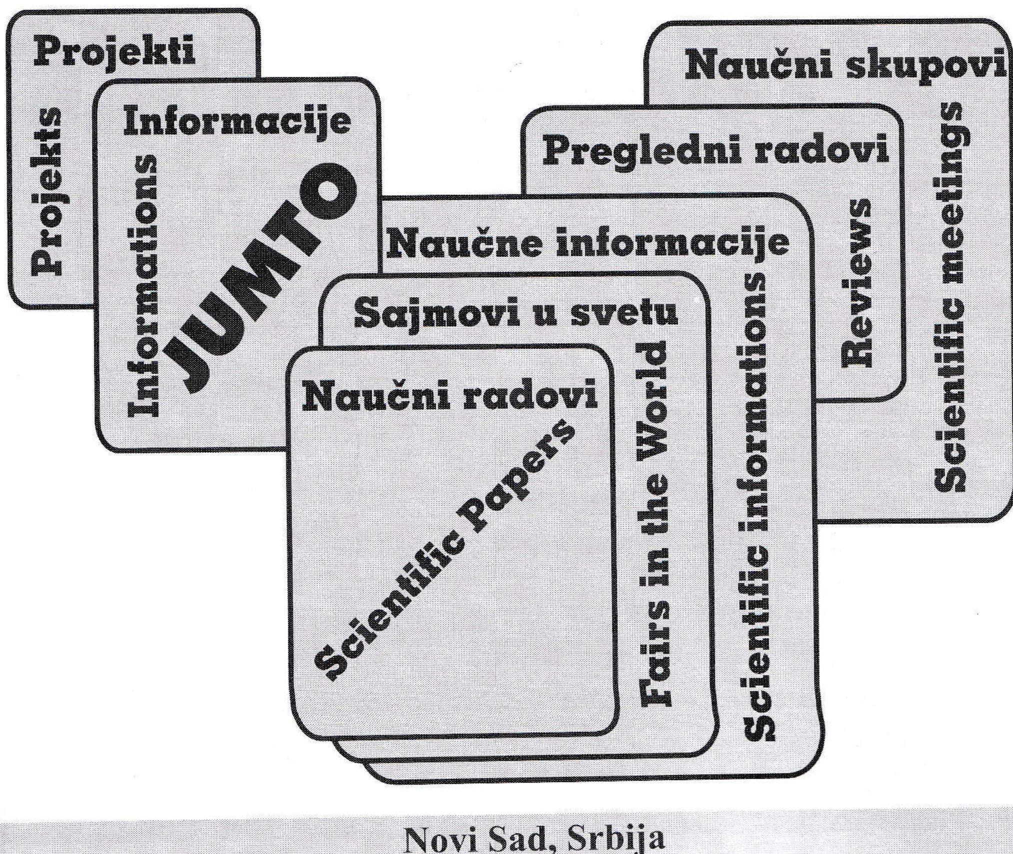
SADRŽAJ - CONTENS



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Naučni rad
Scientific paper

APPLICATION OF DIGITAL HUMAN MODELIN ORDER TO DETERMINE THE FATIGUE AND DISCOMFORT FEELING OF THE TRACTOR DRIVER

Mačužić-Saveljić, S.[1], *Lukić, J.*[2]

SUMMARY

Driver fatigue has a negative impact on driver performance. Modern transport vehicles have become more and more advanced and that is why there are increasing demands for driver comfort. Tractors play an important role in agricultural production, but their working environment can cause a feeling of discomfort. The tractor seat must provide a comfortable position for the driver and does not affect his health and safety. While driving, drivers feel certain vibrations that cause discomfort, back pain and fatigue. A Mc Cormick D326 tractor was used for the analysis. Drivers Fatigue analysis was performed on ten male subjects of the Serbian population. The obtained results showed that the influence of anthropometric data affects the occurrence of fatigue and back pain.A large correlation was observed between the subject's height and fatigue, while a weak correlation was observed between shoulder width and discomfort feeling.

Keywords: Fatigue analysis, Ramsis, Tractor operator, Whole body vibration

INTRODUCTION

Comfort has been widely studied, but a clear definition of comfort has not yet been established. Comfort is a subjective phenomenon and many researchers have studied the factors the impact in subjective feeling of comfort[1], [2]. The influential factors on the ride comfort are: body position, muscle activity, pressure, stiffness, and suspension from seat and back cushions. These studies have concluded that they become a link between comfort and measured factors (age, anthropometry, parts of the body that are in contact, etc.).

Agricultural tractor drivers are exposed to high values of vibrations, which are transmitted to the body. They occur during some daily activities. Whole body vibration (WBV) depends critically on driver's body anatomy, weight distributions, tractor mass, tire inflation pressures and ground. Several studies indicated frequent back injuries of tractor drivers, but did not provide a direct link to vibration exposure, and they did not investigate the effect of driver body position [3], [4]. Some researchers concluded that back pain was a more common disease in 60 tractor drivers who were examined, but they were not sure that vibrations or body

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position were the cause of the pain. The most common disease of the musculoskeletal system is dorsalgia, i.e. back pain, and along the spine and on average occurs in every fifth tractor driver. Dorsalgia may be limited to one or more back-spine areas. Pain, which occurs in the lower back, is felt by as many as 60% to 80% of people during their lifetime, and among tractor drivers, low back pain is present in about 40% of drivers [5], [6]. There is a possibility to get to know in advance the possibilities of the driver's movement while driving as well as the appearance of pain in certain parts of body. The assessment of discomfort is performed by application of digital human models [7]and methods RULA [8], REBA [9], etc. The driver becomes tired while performing various movements while driving.

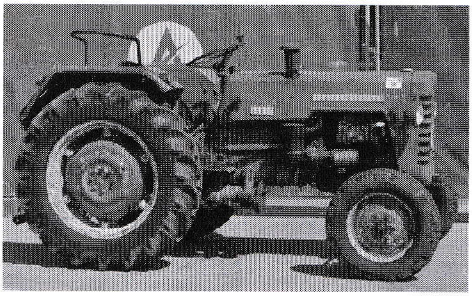


Fig. 1. Tractor McCormikD326

In this paper, digital human models are used to determine thedrivers fatigue and discomfort in certain parts of the body, for different subjects. Ten different male subjects were analysed. Their anthropometric characteristics were varied (body height, sitting height, foot length, arm length). The driving and standstill conditions of all models were tested in a virtual tractor environment (Fig. 1).

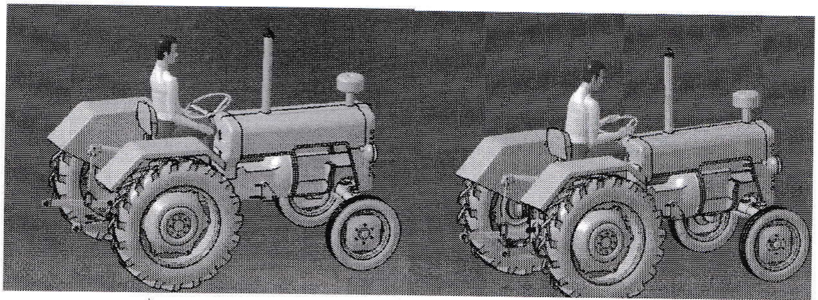
The influence of anthropometric parameters on comfort and fatigue was investigated. For this purpose, the software packages Catiav5R18 and Ramsis (Rechnergestutztes Anthropometerisches Mathematisches System zurInsassen-Simulation) were used. The software package allows you to place the model in a certain position and analyse his comfort/discomfort.

METHODS

Digital human models are increasingly used for testing purposes. The first task of this research was to create a working environment for mannequins on a tractor. A McCormikD326 tractor was modelled because this type of tractor has a good price, which makes it available to a large number of rural households.CatiaV5R18 software package (parts design and assembly modules) was used to model the tractor. The second task was to place the mannequin in a sitting position and set the boundary conditions by application of Ramsis software. Fig. 2 shows a mannequin in a sitting position. Ramsis software has the ability to work with two types of human models - geometric and kinematic. Geometric model of the mannequin with five fingers, and foot legs with shoes were used in this paper. Anthropometric data of the ten subjects are shown in Table 1. The subjects were Serbian populations and belonged to the age group of 18-70 for 99% male populations.

Tab. 1. Anthropometric data of the subjects

	Height (mm)	Sitting height (mm)	Shoulder width (mm)	Foot length (mm)
Subjects	1793.5 ± 21.2	870.8 ± 25.07	463.4 ± 9.4	263.3 ± 3.09



a) b)

Fig. 2.Modelled environment the vehicle: a) resting condition, b) driving condition

While using the tractor, drivers are exposed to negative influences that have a detrimental effect on humans. On the driver's body, in addition to physical stress, various pollutants (dust, plant protection chemicals), and a discomfort has significant factor. Some research [10] shows that, apart from flat asphalt, all other terrains on which tractors move has huge impact on comfort/discomfort. Determination of driving comfort or discomfort in a sitting position can be carried out in field conditions, laboratory conditions and is faced with expensive and time-consuming research on humans. RAMSIS software enables analysis and assessment of vehicle comfort using various human mannequins. An assessment of discomfort can be made in relation to the whole body and different parts of the human body. Discomfort and fatigue is defined by numeric values based on performed experiments. Comfortable sitting and driving is valued as 2.5. Discomfort value assessed higher than 5.5 represents very uncomfortable conditions. The health assessment of the spinal column is based upon an assessment model which converts the posture-related angular misalignment of vertebral bodies against one another into increased pressure loads on the intervertebral disks, from which in turn the model derives a damage assessment. The position of the lumbar spine has the greatest impact on the assessment of health in RAMSIS, while the cervical part of spine has the least impact [11].

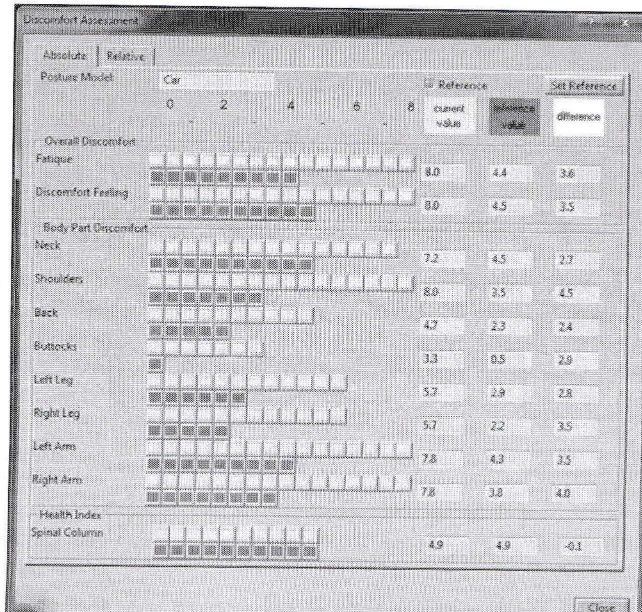


Fig. 3. Results of discomfort assessment

RESULTS

The RAMSIS posture prediction is based on statistical analysis of results obtained from the conducted experiments, [11]. After obtaining the anthropometric data of the virtual driver population, digital human models was generated with appropriate degrees of freedom. By application of abovementioned software and ECE/TRANS/180/Add.3 standards [12], the analysis of the interactions between driver and seat, driver and steering wheel, in order to determine the fatigue and discomfort. The health assessment of the spinal column is based upon an assessment model which converts the posture-related angular misalignment of vertebral bodies against one another into increased pressure loads on the intervertebral disks, from which in turn the model derives a damage assessment.Example of the obtained results is given in Fig. 3. The red rowshows the results while driving, while the yellow row shows the assessment in the resting condition. Difference column represents the difference between red and yellow rows.

Figure 4 show results of the analysis for the driving condition where the dependence of the subject'sfatigue vs. his height was observed. It can be seen that the fatigue values are in the range of 2.2 to 3.9. The highest recorded value of fatigue (3.9) has a subject with a height of 1760 mm, while the lowest has a subject with a height of 1820 mm (Table 2). The coefficient of determination (R^2) was 0.898, and it can be concluded that with increasing height, the fatigue of the subjectsfor the analyzed type of tractor decreases.

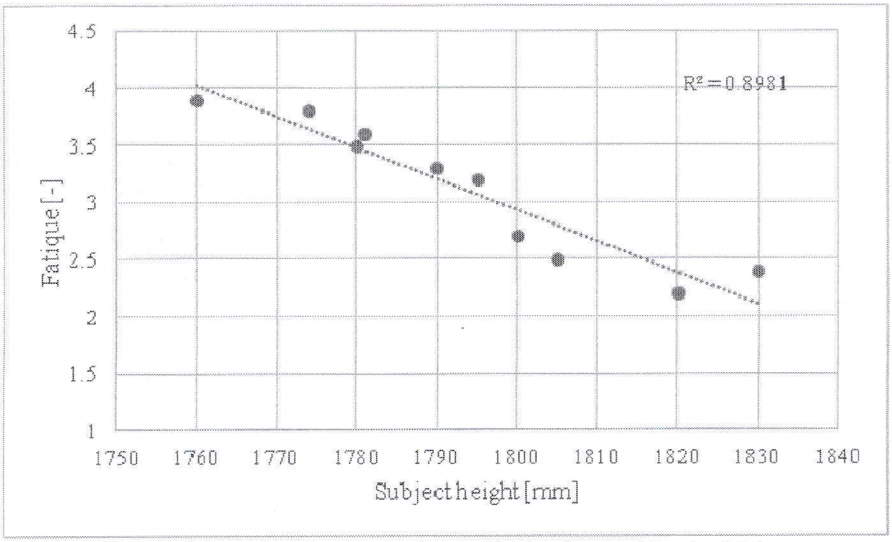


Fig. 4.The results of comparative analysis of ten subjectin driving condition – Fatique vs. subjectheight

Figure 5 show results of the analysis in the driving condition where the dependence of the subject's discomfort feeling vs. his height was observed.The discomfort feeling values was in the range of 2.8 to 4.2. The highest recorded value of discomfort feeling (4.2) has a subject with a height of 1760 mm, while the lowest (2.8) has a subjectwith a height of 1820 mm (Table 2). The R^2 value was 0.909, and, as in the previous case, it can be concluded that with increasing height, the discomfort feeling of the subjectdecreases.Therefore, the higher subject has the lower discomfort feeling values while driving.

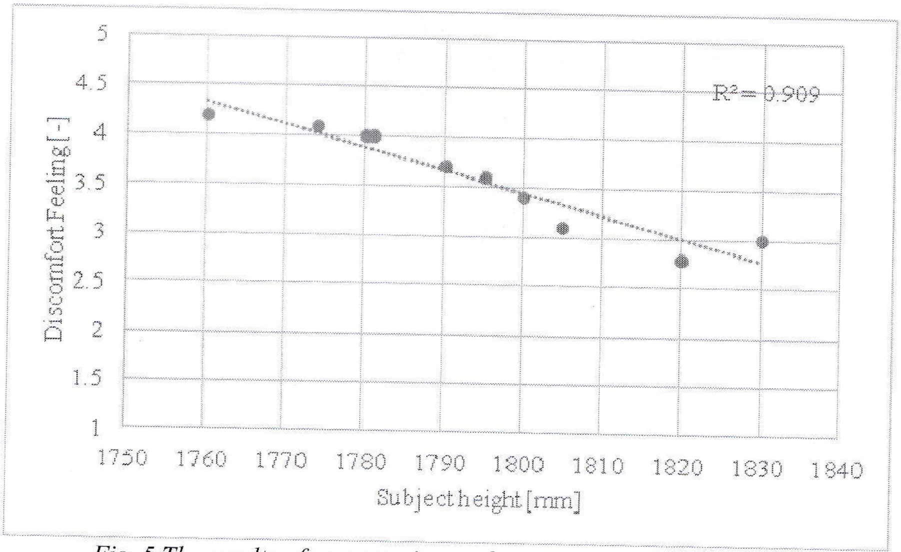


Fig. 5.The results of comparative analysis of ten subjectfor driving condition – Discomfort Feeling vs. subjectheight

Figure 6 shows the results of the analysis for the driving condition where the dependence of the subject's fatigue vs. shoulder width was observed. Fatigue values ranged from 2.2 to 3.9. The highest recorded value of the feeling of fatigue (3.9) has a subject with a shoulder width of 453 mm, while the lowest (2.2) has a subject with a shoulder width of 480 mm. The R^2 value was 0.401. It can be concluded that there is a moderate correlation between fatigue and shoulder width of the subjects.

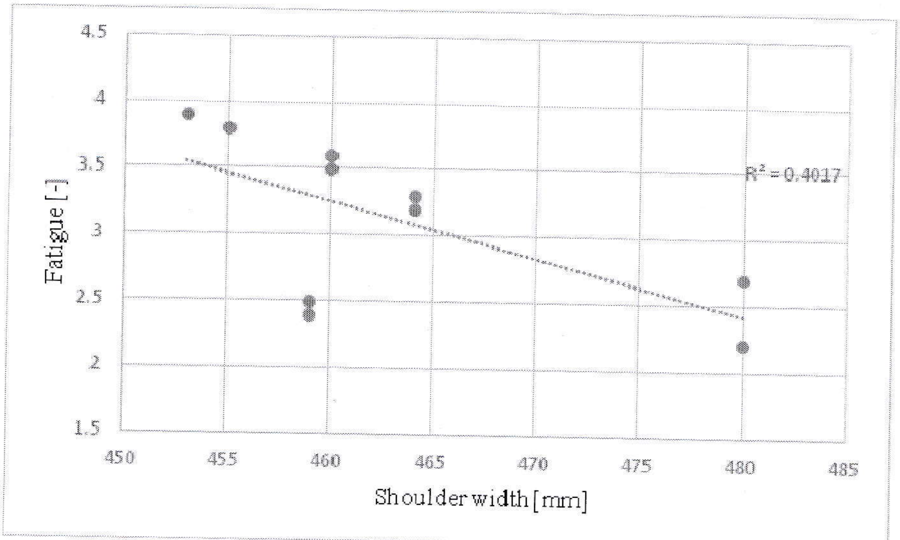


Fig. 6. The results of comparative analysis of ten subjectsfor driving condition – Fatigue vs. subject shoulder width

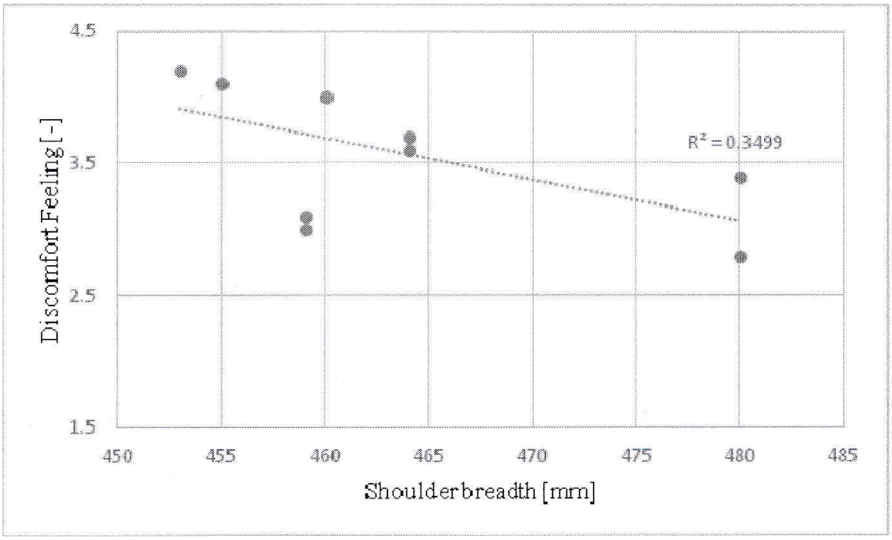


Fig. 7.The results of comparative analysis of ten subjectindriving condition – Discomfort Feeling vs. subject shoulder breadth

A weak correlation (figure 7) was observed in the relationship between the discomfort feeling and the shoulder width of the subjects. Discomfort values ranged from 2.8 to 4.2. The highest recorded value of the feeling of discomfort (4.2) has a subject with a shoulder width of 453 mm, while the lowest (2.8) has a subject with a shoulder width of 480 mm. The value of R^2 was 0.349. This value shows that there is no significant dependence of discomfort feeling and shoulder width of the subjects.

Tab. 2. Descriptive statistics of results obtained for subjects

	Height [mm]	Sitting height (mm)	Shoulder breadth (mm)	Foot length (mm)	Fatigue	Discomfort Feeling
Max	1830	900	480	270	3.9	4.2
Min	1760	810	453	260	2.2	2.8
Mean	1793.5	870.8	463.4	263.3	3.11	3.6
St. deviation	21.2	25.07	9.4	3.09	0.6	0.5

As the analyzed values of fatigue and discomfort mostly in the range from 2.5 to below 5.5, it is considered that this driving condition is acceptable for the subjects of the analyzed anthropometric dimensions, figure 8.

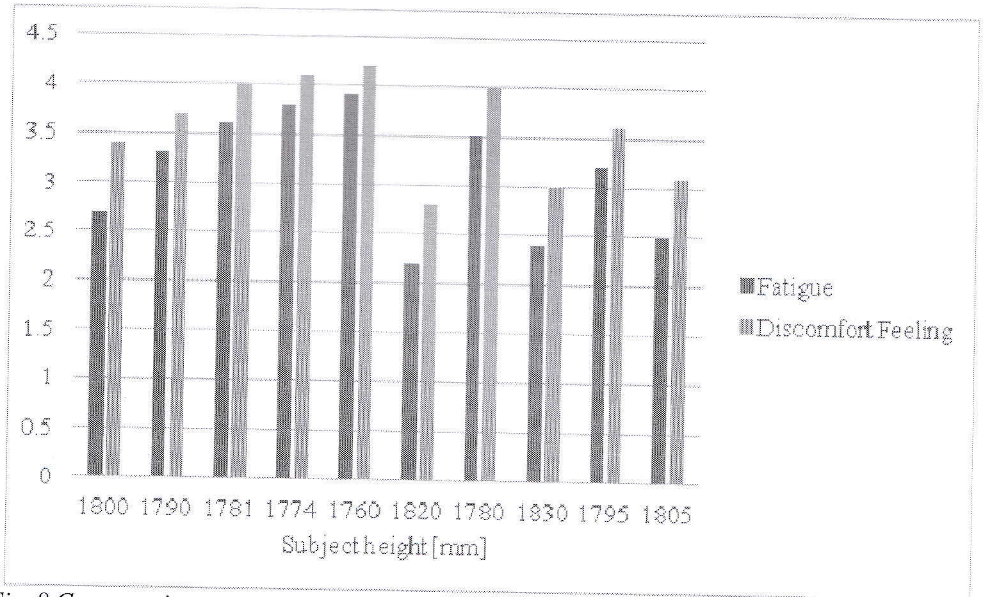


Fig. 8.Comparative presentation of the influence of fatigue and discomfort for ten subjectswith different anthropometric dimensions

Figure 8 show the values of fatigue and discomfort feeling for the ten subjectsused in this study. Based on the obtained results of fatigue and discomfort feeling, it can be concluded that the increase in fatigue is accompanied by an increase in discomfort feeling, but the tractor used in this work corresponds to the examined small population, because the analyzed data do not exceed the allowed limit values.

CONCLUSIONS

The aim of this study was to determine the driver fatigue and discomfort feeling for a given type of tractor in driving condition. The anthropometric dimensions of tensubjectswere analysed. Testing was done in the software package Ramsis. The obtained results show that all subjectshave a permissible fatigue value below 5.5, which represents a limit value. The fatigue values were in the range of 2.2 to 3.9. The highest recorded value of fatigue has a subjectwith a height of 1760 mm, while the lowest value of 2.2 has a subjectwith a height of 1820 mm, in range of 2.5-5.5 for comfortable sitting. The R^2 value was 0.898, and it can be concluded that with increasing height, the fatigue of the subjectsfor the analyzed type of tractor decreases. Discomfort feeling study show the values range of 2.8 to 4.2. The highest recorded value of 4.2 has a subjectwith a height of 1760 mm, while the lowest value of 2.8 has a subject with a height of 1820 mm. The R^2 value was 0.909, and, as in the previous case, also can be concluded that with increasing height, the discomfort feeling of the subject'sdecreases.It was concluded that there is a moderate correlation betweenfatigue and shoulder width of the subjects, and weak correlation between the discomfort feeling and the shoulder width.

The application of this method of analyzing fatigue or feelings of discomfort has a number of advantages. First, it is possible to determine which population can best use the product with minimal feelings of discomfort. Secondly, tractor manufacturers can know in advance how the drivers will interact with the work vehicle, and do everything to adapt the product to a larger number of users.

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