The Subjective Analysis of the Main Workload Dimensions in the Company from the Transportation Industry

Rafał Michalski and Katarzyna Jach

Institute of Organization and Management (I23)
Wrocław University of Technology
Wrocław, 50-370, Poland

ABSTRACT

This research is focused on determining the relative importances of diverse work dimensions and their attributes in a large company producing transportation vehicles. Fifty four employees from three different departments took part in this examination. They were all males with significant work experience in the current post and overall in the company. The obtained results were investigated both for all of the examined workers as well as individually for a number of various professions. The whole study was conducted within the Subjective Overall Workload Assessment (SOWA) framework and included the analysis of the manual material handling, body posture and movements, work environment, and mental requirements. The applied method allowed for identifying crucial areas in which immediate ergonomic interventions are necessary. Moreover, it was also possible to specify the hierarchy and order of the issues of ergonomic nature that should be addressed in the longer term.

Keywords: workload, transportation industry, subjective assessment

INTRODUCTION

It is widely acknowledge that the excessive workload may have negative effects both on the work effectiveness and efficiency. The impact on the human being health and subjective feeling has also been confirmed in numerous studies. The workload is multi-aspect term, consists of many dimensions and may be analyzed both objectively as well as subjectively (Chang and Chen, 2006). There are a number of methods available in this area, for instance, NASA Task Load Index (Hart & Staveland, 1988), Lin and Hwang (1998), Multiple Resources Questionnaire (Boles and Adair, 2001), Jung and Jung (2001), Subjective Workload Assessment Technique (Luximon and Goonetilleke, 2001), Workload Profile (Phillips and Boles, 2004) or The Integrated Workload Scale (Pickup et al. 2005).

Among the recent proposals of overall subjective workload evaluation there is a work of Michalski and Grobelny (2007) which was applied in this research. The method evaluates the workload in four main dimensions: manual material handling, material work environment, body posture and movement, and mental demand environment. Each of these dimensions is characterized by several parameters. The detailed structure along with the full description of this technique can be found in the work of Michalski and Grobelny (2007) or Grobelny et al. (2008).

METHOD

Participants

An overall number of 54 workers from seven different types of posts took part in the examination. They all were employed in one of the branches of the company situated in Wrocław (Poland) which operates worldwide in the rail transportation sector. Because of considerable mistakes, the questionnaires of two participants (4%) were rejected. The basic statistical characteristics of the remaining subjects are presented in Table 1. Generally, they were in their middle ages and had significant work experience both overall and at the current post.

Table 1. Age ranges of participants.

	Mean (years)	Standard deviation (years)
Age	41.3	8.9
Overall work experience	22.8	9.5
Current post work experience	12.6	9.9

Apparatus

Custom made software supporting the SOWA technique was used to automatically generate questionnaires and to make the computations of the preference weights in all the examined workload dimensions. The software created in Microsoft Visual Basic 6.0 environment all necessary data were stored in a database file.

Procedure

The subjects filled in paper versions of the questionnaires generated automatically by the SOWA supporting software. The questionnaires included a personal details questions, workload attributes assessment items, pairwise comparisons. Participants compared parameters within workload dimensions first and then on the whole dimensions. The order of questions was randomized.

The overall time needed to complete the questionnaires took about 20 minutes. The participants were encouraged to ask questions anytime while completing the questionnaire and they received help immediately. The data from collected questionnaires were next entered into the supporting software and then analyzed.

The dependent measures reflected the subjective preferences expressed by examinees and were obtained according to the Analytic Hierarchy Process (Saaty, 1980) framework and was based on calculating the eigenvectors of the pairwise comparison matrices. The vector of weights includes values ranged from zero to one therefore their mean values are demonstrated as percentages. The bigger the weight, the more preferred the given variant was.

RESULTS AND DISCUSSION

The overall averaged results regarding the workload subjective perception in the investigated company are put together in Table 2 and graphically presented in Figure 1. The applied methodology, allowed for obtaining not only final mean preferences towards examined workload dimensions an attributes but also the relative importance of the dimensions.

Table 2. Weights and weighted scores of workload dimensions for all subjects.

No.	Workload main dimensions	Weights (%)	Weighted scores (%)
1.	**Manual material handling**	30	15.8
2.	**Material work environment**	20	15.2
3.	**Body posture and movement**	39	31.5
4.	**Mental demand**	10	8.1

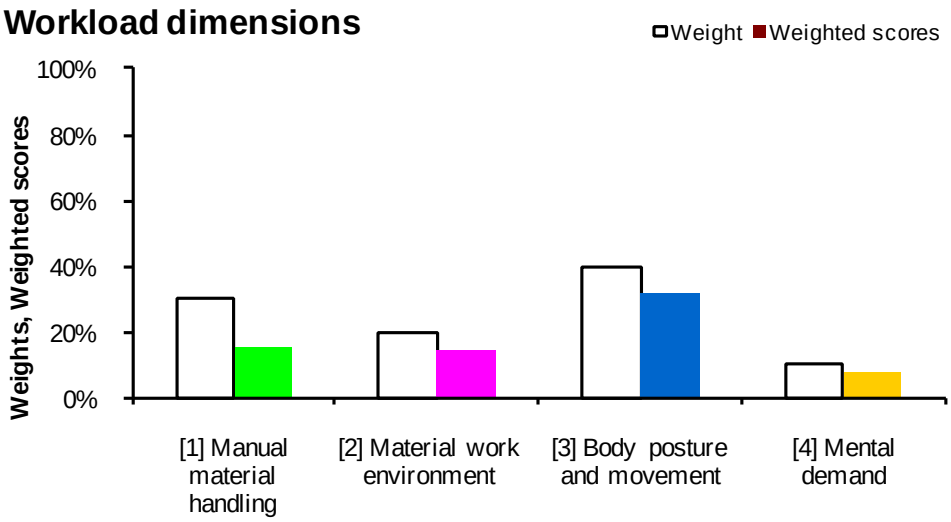

Figure 1. All subjects mean weights and weighted scores (%).

The results show unequivocally that the *Body posture and movement* dimension has the decidedly strongest influence on the subjective workload perception. The *Manual material handling* along with *Material work environment* are in the second place with nearly identical values which are almost two times lower that the mean scores for the *Body posture and movement* dimension. The least scores were assigned to the *Mental demand* factor. Analyzing the weights computed for the dimensions one may notice that the second most important dimension is the Manual material handling, but the weighted score in this case is considerably lower that it could be expected. This finding may indicate that this dimension is crucial to the workers, however, the existing work organization and applied ergonomic measures make this issue more acceptable.

Table 3. Manual material handling weighted scores

1. Manual material handling	Weighted scores (%)
1.1. Weight of load	**21.4**
1.2. Frequency of load	11.6
1.3. Duration of load	8.0
1.4. Moving distance of load	9.6

Table 4. Material work environment weighted scores

2. Material work environment	Weighted scores (%)
2.1. Microclimate	18.5
2.2. Lighting	5.2
2.3. Noise	**32.6**
2.4. Vibrations	10.7
2.5. Exposure to chemicals	7.9

Table 5. Body posture and movement weighted scores

3. Body posture and movement	Weighted scores (%)
3.1. Standing	15.1
3.2. Stooping	23.6
3.3. Squatting, kneeling	**24.6**
3.4. Twisting	15.6

Table 6. Mental demand weighted scores

4. Mental demand	Weighted scores (%)
4.1. Time load	**46.9**
4.2. Mental effort load	8.5
4.3. Psychological stress load	19.6

Further analysis of the results regards the assessment of the dimensions' attributes. The final weighted scores are demonstrated in Tables 3 to 6. Within the most important dimension of *Body posture and movement*, the *squatting and kneeling* along with *stooping* are markedly more important than the remaining two attributes. *Standing* and *Twisting*, however, are also on a significant level of about 15%. In *Manual material handling* only one parameter predominate, that is *Weight of load* with the score of more than 21%. Similar situation is in *Material work environment* where the *noise* attribute prevails over the others. In the least important *Mental demand* dimension, the *Time load* occurred to be the most influential factor.

The described above results pertain to the subjects as a whole, however for the company's managers it was very interesting how the workload perceptions differ between employees working in various departments. The outcomes of such a analysis is provided in Table 7.

Table 7. Overall results for all subjects and subjects having strongly consistent preferences

No	Workload main dimensions	Weighted scores (%)						
		DODA Department Worker	**Sprayer**	**Logistician**	**Straightener**	**Welder**	**Locksmith**	**Welder - Locksmith**
1.	**Manual material handling**	**27.4**	7.9	**20.7**	15.2	14.4	15.9	17.1
2.	**Material work environment**	5.0	24.5	10.4	10.7	14.6	16.6	15.5
3.	**Body posture and movement**	**25.2**	**40.1**	**20.8**	**41.8**	**30.9**	**26.8**	**30.5**
4.	**Mental demand**	4.3	5.5	18.6	4.1	10.1	11.1	4.6
	Sum:	**61.9**	**78**	**70.5**	**71.8**	**70**	**70.4**	**67.7**

The presented above workload dimension weighted scores for seven groups of workers are generally consistent with averaged values obtained for all participants, however some differences may be observed. In all but DODA department employees the biggest impact on perceived workload had the *Body posture and movement* dimension. The scores, however, varied significantly between professions with the range of as much as 21 percentage points - 41.8% for straighteners and 20.8% for logisticians.

The results for two groups: DODA department workers and logisticians exhibit also a considerably different structure than the rest of the analyzed professions. In these two cases: *Manual material handling* was as important as the *Body posture and movement*. The overall sum of the weighted scores presented in the last row of the Table 7 may be interpreted as an indicator of the workload levels in individual groups of workers. The biggest value was obtained for sprayers whereas the lowest for the DODA department workers.

CONCLUSIONS

The applied subjective workload assessment technique, though relatively simple and general enables the managers to identify the most critical areas where ergonomic interventions might be required. Secondly, since the method is based on the Analytic Hierarchy Process it also allows for determining the order of addressing problems that arise from workload dimensions and their components.

The obtained results suggest that immediate actions should be taken to decrease the influence of the *Body posture and movement* on the workload level. Within this dimension, the particular focus should be given to *squatting, kneeling* and *stooping*. They may include workplace rotation or job enrichment. The next priority should set *Manual material handling* activities, especially to *weight of load*. In this area some it may be necessary to review how heavy objects are transported and if necessary to purchase appropriate supporting devices. Additionally, on-site professional training might be of use.

In the longer run the measures should also be taken in the third dimension regarding the *Material work environment* – here, generally, the noise seem to be the most important factor. For sprayers and logisticians, however, some actions concerned with the *exposure to chemicals* and *microclimate* should be taken instantly – if possible.

One ought to remember that the results obtained by means of this method should be treated as the first step to alleviate the negative effects concerned with the workload. Such an approach is not meant for replacing objective methods of examining various aspects of the workload. It should rather be treated as a complementary measure that facilitates setting correct priorities.

REFERENCES

Boles D.B., Adair L.P. (2001). The Multiple Resources Questionnaire (MRQ), in: Proceedings of the Human Factors and Ergonomics Society, 45, , pp. 1790–1794.

Chang S.Y., Chen T.H. (2006). Discriminating relative workload level by data envelopment analysis, International Journal of Industrial Ergonomics 36, 773–778.

Grobelny J., Michalski, R., Karwowski, W. (2008). Workload Assessment Predictability for Digital Human Models. In: V. Duffy (Ed.), Handbook of Digital Human Modeling, pp. 28.1 – 28.13. CRC Press.

Hart S.G., Staveland L.E., (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research, in: Human Mental Workload, P.A. Hancock, N. Meshkati, eds, Elsevier, Amsterdam, pp. 139–183.

Jung H.S., Jung H.-S. (2001). Establishment of overall workload assessment technique for various tasks and workplaces, International Journal of Industrial Ergonomics 28, 341–353.

Lin D.Y., Hwang S.L. (1998). The development of mental workload measurement in flexible manufacturing systems, Human Factors and Ergonomics in Manufacturing 8, 41–62.

Luximon A., Goonetilleke R.S. (2001). Simplified subjective workload assessment technique, Ergonomics 44, 229–243.

Michalski, R., & Grobelny, J. (2007). Computer-aided subjective assessment of factors disturbing the occupational human performance. Occupational Ergonomics, 7(1), 27–42.

Phillips J.B., Boles D.B. (2004). Multiple resources questionnaire and workload profile: Application of competing models to subjective workload measurement, in: Proceedings of the Human Factors and Ergonomics Society, 48, pp. 1963-1967.

Pickup L., Wilson J.R., Norris B.J., Mitchell L., Morrisroe G. (2005). The Integrated Workload Scale (IWS): A new self-report tool to assess railway signaller workload, Applied Ergonomics, 36, 681–693.

Saaty, T.L. (1980). The analytic hierarchy process, McGraw Hill, New York.