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The relations between work demands and health complaints in lorry drivers

A model tested by means of LISREL

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Abstract In this study, data of a questionnaire study among 439 lorry drivers were fitted to a model in which work demands and the worker's decision latitude are related to musculoskeletal complaints and general psychosomatic complaints. Structural analysis with LISREL was used to investigate the hypothesized relations. Two modifications resulted in a χ^2 of overall fit equal to 77.35 with 47 degrees of freedom. The quality of model fit was considered to be satisfactory when the sample size was taken into account. The values of the Adjusted Goodness of Fit Index (0.948) and the Root Mean Square Residuals (0.029) indicated the same. The standardized solution of LISREL showed that work demands with respect to task contents were significantly related to musculoskeletal complaints as well as to general psychosomatic complaints (0.75 and 0.34 respectively, both $P < 0.001$). This conceptual variable was indicated by physical activities that the drivers had to perform. The relations between work-related psychosocial factors and musculoskeletal complaints were weak. Another significant effect on general psychosomatic complaints was found for work demands with respect to terms of employment (0.30, $P < 0.001$). This conceptual variable was indicated by variables concerning working hours and pressure of the work. It is recommended that in future occupational epidemiology, both physical and psychosocial aspects of the working situation be related to health effects, rather than solely a single exposure variable.

Key words Physical workload · Psychosocial factors
Health complaints · LISREL · Lorry drivers

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Introduction

Various epidemiological studies indicate that work with a high physical workload and/or exposure to other occupational risk factors is associated with musculoskeletal complaints and other disorders (Hagberg 1992). The process in which the work situation evokes responses in the human organism is described in many models. Some emphasize physical aspects (e.g., Chaffin 1988) while others stress psychological and organizational aspects (e.g., Karasek and Theorell 1990). Recently, a simple dose-response model that incorporates (interactions between) all kinds of aspects was presented by Armstrong et al. (1993). Another model that aims to incorporate physical as well as psychological and organizational aspects of the work was previously developed by Van Dijk and colleagues (1990). The latter modes was considered to be most appropriate for this study, because it pays considerable attention to the working situation. In the model (Fig. 1) the working situation is characterized by (a) work demands and (b) the worker's decision latitude.

Work demands can be differentiated according to task contents, working conditions, terms of employment, and social relationships at work. Decision latitude is the extent of autonomy and opportunities for the worker to improve (or to worsen) the working situation by altering the work demands. The working situation in combination with the work capacity causes short-term effects and possibly long-term effects in the worker. Short-term effects, such as increased heart rate, elevated blood pressure, increased production of adrenaline, and feelings of fatigue, are indicators of the workload. They represent the load of the organism during work and some hours thereafter. Under normal conditions the worker is capable of coping with the work demands and adequate recovery takes place before a new period of working starts. In the case of insufficient recovery, short-term effects give rise to long-term effects. Examples of these more permanent effects are musculoskeletal complaints, chronic fatigue, psychosocial problems, disease, or disablement. Negative effects may result

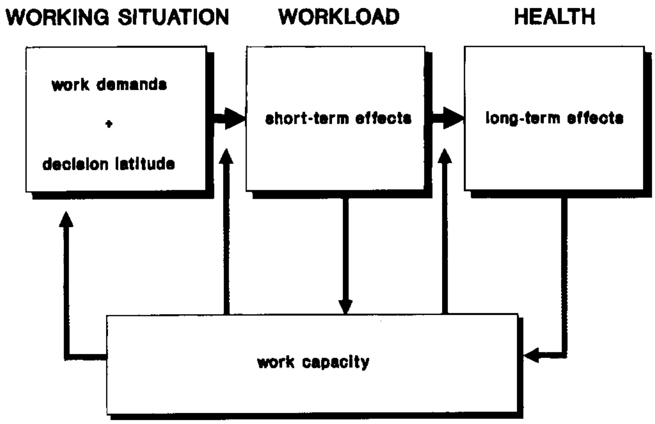

Fig. 1 Model of workload and capacity (Van Dijk et al. 1990)

in decreased capacity of the worker. On the other hand, effects such as improvement of skills or physical condition lead to positive changes in the worker's capacity. The above-described model has been used as a theoretical framework (Van Dormolen et al. 1990; Paul et al. 1994), but research confirmation of the model is still needed.

In the past, most epidemiological studies on work-related musculoskeletal disorders focused on a single risk factor, usually an aspect of physical workload (Burdorf 1992). These studies failed to adjust for confounding variables, like work-related psychosocial aspects. Bongers et al. (1993) reviewed the epidemiological literature and concluded that several psychosocial factors at work are related to musculoskeletal symptoms, although no conclusive evidence was found. This was due to, among other things, the fact that several of the reviewed studies did not adequately control for other risk factors, including physical load. In summary, it is now generally agreed that multivariate statistical analysis has to be applied in order to amass knowledge of the multifactorial origin of work-related health problems. Controlled experimental studies are not adequate for the analysis of these complex processes, because normally in such studies only isolated sections of the total causal structure of the process under consideration are investigated. Structural-equation models that are used in the LISREL method are developed especially for the analysis of data which are collected under non-experimental conditions. Consequently, in this study diverse aspects of the working situation (i.e., work demands and decision latitude) are included, and related to health complaints by means of LISREL. The aims of this analysis of data that originated from a questionnaire study among lorry drivers were (a) to investigate whether these data fit to a model in which different aspects of the working situation are related to health complaints, and (b) to obtain an impression of the relative contribution of these aspects to health complaints.

Table 1 The observed variables with their number of items and in the case of a scale Cronbach's α

		No. of items	Cronbach's α
x_1	Perceived difficulty with stooping or working in a bended posture, working in an uncomfortable position, lifting, and carrying or lugging	4	0.83
x_2	Perceived difficulty with sitting, standing, walking, and stair-climbing	4	0.68
x_3	Perceived difficulty with pushing and pulling	2	0.88
x_4	Perceived hindrance of climatic working conditions	6	0.81
x_5	Perceived hindrance of, e.g., dust, exhaust fumes, stench, noise, smear	7	0.80
x_6	Perceived problems with working hours	5	0.78
x_7	Perceived pressure of work	8	0.84
x_8	Perceived social relationships at work[a]	3	0.59
x_9	Perceived decision latitude[a]	8	–[b]
y_1	Pain or stiffness in the neck and upper limbs	7	0.79
y_2	Pain or stiffness in the lower limbs	1	–
y_3	Pain or stiffness in the back	1	–
y_4	General psychosomatic complaints, excluding musculoskeletal complaints	19	0.87

[a] Unlike the other variables, in this variable a high score was favorable

[b] This variable was the sum of the z-values of two scales, i.e., participation (Cronbach's α = 0.67) and autonomy (Cronbach's α = 0.58)

Materials and methods

Subjects and questionnaire

A questionnaire was sent to 1 000 Dutch lorry drivers; details of the procedure and the origin of the study population are given elsewhere (Van der Beek et al. 1993). Complete data on the variables that were used in this study were obtained for 439 of the 534 responding lorry drivers. The average age of these drivers was 35.4 years (SD: 9.5; range: 19 – 60).

The questionnaire addressed the working situation of lorry drivers and the long-term health effects, encompassing working conditions and difficulties with loading and unloading, musculoskeletal complaints, and general health. Most of the questions that were relevant for the present study were originally adopted from other, existing questionnaires. All of the questions on perceived hindrance of working conditions and on musculoskeletal complaints and some of the questions on perceived difficulty with activities were taken from the questionnaire Periodic Occupational Health Survey (Weel et al. 1989). A Dutch version of the questionnaire on job demands and job decision latitude (Karasek 1979) provided the scales concerning perceived pressure of work, decision latitude, and social relationships at work. A widely used general health questionnaire (Dirken 1967) was included; this so-called VOEG measures somatized psychosocial problems (Visser 1983). However, among the 21 items of the VOEG are two questions concerning the musculoskeletal system (pain in the back and pain in bones and muscles). In order to draw a sharp distinction between perceived general health with a psychosocial background and musculoskeletal complaints, these two questions were excluded from the VOEG score.

Twenty lorry drivers were structurally interviewed and most of them were also observed during a whole working day. By means of this task analysis it appeared that, altogether, 11 scales and two single questions were appropriate to indicate conceptual variables from the model of Van Dijk et al. (1990). In Table 1 an overview of these 13 observed variables is shown, with the number of items and Cronbach's α in the case of a scale. Except for the variables x_8 and x_9, for all variables a high score meant that many problems were perceived.

LISREL

In this study LISREL VII (Jöreskog and Sörbom 1989) was used to investigate whether the data fitted to the specified model. The full LISREL model for single samples is defined by the following three equations:

$\eta = B\eta + \Gamma\xi + \zeta$ (the structural equation model)
$y = \Lambda_y\eta + \varepsilon$ (the measurement model for y)
$x = \Lambda_x\xi + \delta$ (the measurement model for x)

The model specifies a linear structural relationship between latent dependent variables (η) and latent independent variables (ξ). These latent variables are not measured, but are indicated by one or more observed variables. In more concrete terms, in the model the values of the observed indicator variables (the x's and y's) are thought to arise from the underlying conceptual variables (the ξ's and η's respectively). The model coefficients B, Γ, Λ_x and Λ_y express the relations between the different variables. Furthermore, the model involves errors in equations (the ζ's) and errors in variables (the ε's and δ's).

Data analysis

In Fig. 2 the second model that was tested by means of LISREL is shown, for the observed indicator variables (the x's and y's) referred to in Table 1.

Only the relations between the working situation (work demands and decision latitude) and long-term health effects could be tested, because the questionnaire concerned neither the worker's capacity nor short-term effects. Therefore, in the present study the full model of Van Dijk et al. (1990) could not be tested. In the tested part of the model the latent variables ξ_1 to ξ_4 concerned work demands, differentiated according to task contents (ξ_1), working conditions (ξ_2), terms of employment (ξ_3) and social relationships at work (ξ_4). The worker's decision latitude was expressed in the latent variable (ξ_5). Musculoskeletal complaints were expressed in the latent variable η_1, whereas latent variable η_2 concerned general psychosomatic complaints. The underlying idea for the latent variables was that the presence of, for instance, work demands with respect to working conditions (ξ_2) had an effect on perceived hindrance of working conditions (x_5). Thus the arrows are directed from the latent variables to the observed indicator variables.

All relations between the latent independent variables (ξ's) and the latent dependent variables (η's) were specified. Furthermore, all possible relations between the five ξ-variables were specified, but these arrows are not shown in Fig. 2 for the sake of clarity. With reference to, among others, Bongers et al. (1993), an attempt was made to specify a reciprocal relationship between both η-variables (musculoskeletal complaints and general psychosomatic complaints). However, the output of LISREL clearly indicated an estimation problem with respect to this reciprocal relationship. In order to obtain an identifiable model, at least one of the relationships between the η-variables (i.e., one of the β coefficients) had to be fixed at zero (see Saris and Stronkhorst 1984). The question of whether (a) general psychosocial complaints are a result of the persistence of musculoskeletal complaints or (b) general psychosocial complaints have an etiologic role in the development of (chronic) musculoskeletal complaints is still unsolved in the epidemiological literature. Therefore, it was decided to fix both β coefficients at zero and to specify the correlation between the equation errors (ζ's).

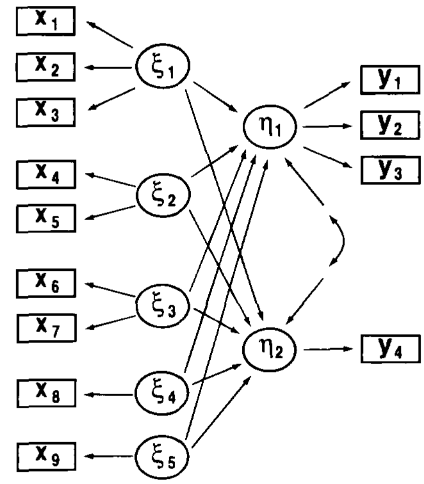

Fig. 2 The second tested model with the following latent variables: task contents (ξ_1), working conditions (ξ_2), terms of employment (ξ_3), social relationships at work (ξ_4), decision latitude (ξ_5), musculoskeletal complaints (η_1), and general psychosomatic complaints (η_2) (for observed x- and y-variables see Table 1)

Three measures of the overall goodness of the model's fit were used: χ^2, Adjusted Goodness of Fit Index (AGFI), and Root Mean Square Residuals (RMSR). The χ^2 measure is used as a statistic for testing the correctness of the model against the alternative that the model should be rejected as ill fitting. If, given that the model is correct, the probability of a greater χ^2 value than the obtained value is less than the 0.05 level of significance, the model is not acceptably fitting. However, large sample sizes are likely to produce significant χ^2's, because smaller differences are detectable as being more than mere sampling fluctuations. Therefore, it has been generally accepted that χ^2 should be expressed relative to the degrees of freedom (Jöreskog and Sörbom 1989). Carmines and McIver (1981) suggested that χ^2 must be larger than two or three times the degrees of freedom before rejecting a model as ill fitting. With reference to a formula provided by Hoelter (1983), Hayduk (1987) recommended that one should insert simply $n = 200$ into the LISREL program and use the χ^2 that results. Both strategies with respect to χ^2 were applied in this study. AGFI was included because it is less sensitive than χ^2 to sample size and departures from multivariate normality of the observed variables. The RMSR can be used to compare the fit of different models for the same data (Jöreskog and Sörbom 1989). In this study the quality of model fit was considered reasonable with AGFI greater than 0.90 and, after standardization, RMSR less than 0.05.

Results

In Table 2 the test statistic χ^2, with degrees of freedom and probability, and the goodness of fit measures AGFI and RMSR are shown for two tested models.

Table 2 The test statistic χ^2 with degrees of freedom (*df*) and probability (*P*), and the goodness of fit measures AGFI and RMSR for two fitted models ($n = 439$)

	χ^2	*df*	*P*	AGFI	RMSR
Model 1	132.50	59	< 0.001	0.924	0.037
Model 2	77.35	47	< 0.01	0.948	0.029

Table 3 The second model's coefficients for the relations between the latent variables and the observed indicator variables. The errors in the indicator x- and y-variables are shown within parentheses

Latent variable	Coefficient	Indicator variable	Error
Task contents (ξ_1)	0.72	Difficulty with stooping or working in a bended posture, lifting, etc. (x_1)	(0.48)
	0.63	Difficulty with sitting, standing, walking, etc. (x_2)	(0.61)
	0.54	Difficulty with pushing and pulling (x_3)	(0.71)
Working conditions (ξ_2)	0.65	Hindrance of climatic working conditions (x_4)	(0.57)
	0.71	Hindrance of, e.g., dust, exhaust fumes, stench, noise, smear (x_5)	(0.49)
Terms of exployment (ξ_3)	0.74	Problems with working hours (x_6)	(0.46)
	0.78	Pressure of work (x_7)	(0.39)
Social relationships at work (ξ_4)	1.00[a]	Social relationships at work (x_8)	(–)[b]
Decision latitude (ξ_5)	1.00[a]	Decision latitude (x_9)	(–)[b]
Musculoskeletal complaints (η_1)	1.11	Pain or stiffness in the neck and upper limbs (y_1)	(0.64)
	1.12	Pain or stiffness in the lower limbs (y_2)	(0.63)
	1.00[a]	Pain or stiffness in the back (y_3)	(0.71)
General psychosomatic complaints (η_2)	1.00[a]	VOEG, excluding musculoskeletal complaints (y_4)	(–)[b]

[a] This coefficient had to be fixed
[b] The error in this variable could not be specified in the model

Table 4 The standardized solution of LISREL for the relations between the latent independent variables and the latent dependent variables in the second model

	Musculoskeletal complaints (η_1)	General psychosomatic complaints (η_1)
Task contents (ξ_1)	0.75*	0.34*
Working conditions (ξ_2)	0.17	0.15
Terms of employment (ξ_3)	0.07	0.30*
Social relationships at work (ξ_4)	0.13	–0.01
Decision latitude (ξ_5)	–0.07	0.01

* $P < 0.001$ (two-sided z-test)

In the first place the data were fitted to a model (model 1) that was clearly improvable. In this initial model pain or stiffness in the neck and pain or stiffness in the upper limbs were two separate y-variables, but LISREL's modification index indicated that these variables should be joined, because they had too much in common. The value of this index, which is a measure of predicted decrease in χ^2 if a single modification is made and the model is reestimated, was 28.72. There were no theoretical objections to following this recommended modification. Furthermore, it appeared that variable x_7 (perceived pressure of work), which was originally an additional indicator of decision latitude (ξ_5), was not properly placed in the model. On theoretical grounds the placement of perceived pressure of work was revised so that it became an additional indicator of terms of employment (ξ_3). The modification index of LISREL for this improvement was 9.05. After these two modifications the resulting model (model 2, see Fig. 2) was fitted again, which resulted in a χ^2 of overall fit equal to 77.35 with 47 degrees of freedom. This was statistically significant, indicating that this model did not fit the data and should be rejected. However, both strategies that took the sample size into account gave rise to the conclusion that the model should not be rejected as ill fitting. The AGFI and RMSR were 0.948 and 0.029 respectively, which was also an indication of an acceptable quality of model fit.

The second model's coefficients for the relations between observed indicator variables and latent variables (Λ_x and Λ_y) and all errors in the indicator x- and y-variables (the δ's and ε's respectively) are shown in Table 3. All of these coefficients and errors were statistically significant ($P < 0.001$). The equation errors (ζ's) were 0.05 for η_1 (musculoskeletal complaints) and 0.56 for η_2 (general psychosomatic complaints); both were statistically significant ($P < 0.05$ and $P < 0.001$ respectively). The ζ's were significantly correlated (0.08, $P < 0.001$).

The standardized solution of LISREL for the relations between the latent independent variables (ξ's) and the latent dependent variables (η's) is shown in Table 4. The effect from ξ_1 (task contents) on η_1 (musculoskeletal complaints) was equal to 0.75 which was statistically significant. Significant effects on η_2 (general psychosomatic complaints) were found for ξ_1 (task contents) and ξ_3 (terms of employment): 0.34 and 0.30 respectively. The other relations were not statistically significant.

Discussion

Subjects and questionnaire

In this study only one occupational group was represented, i.e., lorry drivers, who have a specific working situation. Moreover, lorry drivers have their own individual characteristics and work capacity, which may be due to health-based selection. Although this single occupational group is advantageous with respect to the internal validity of this study, generalization to other occupations is not yet permissible, because in other groups the relationships between the working situation and health effects may be different.

The inter-item homogeneity, assessed with Cronbach's α coefficient, was satisfactory for all scales except for the scale perceived social relationships at work. Overall, it is considered that the conclusions of this study should be treated with some caution.

LISREL

Boomsma (1983) concluded that, given a sample size of 400, the maximum likelihood estimation procedure of LISREL is robust against categorization of the observed variables, but not against rather skew distributions of those measurements. In the present study the sample size was 439, but some of the observed variables were not symmetrically distributed. While there are variants of LISREL, e.g., the Generally Weighted Least-Squares method, with very mild assumptions concerning the distribution of the measured values of variables, these variants present several difficulties in practical applications (Jöreskog and Sörbom 1989). Thus, it was decided to use the classical maximum likelihood method.

The output of LISREL concerning the "effect" on a variable from another variable should be interpreted as the magnitude of change in the variable that would be predicted to accompany a unit change in the other variable with the rest of the variables left untouched at their original values. In cross-sectional studies the causal interpretation of LISREL (like any other multivariate statistical method) is fundamentally incorrect. However, the closer the match between the model specifications of dependent and independent variables and the real causes and effects, the more reasonable the change-resulting-in-an-effect terminology (Hayduk 1987). In this cross-sectional study no real causal relations could be determined; this requires a longitudinal cohort study.

One of the advantages of LISREL is that the estimated relations are differential, i.e., the standardized solution provides a clear insight into the magnitude of the relationships compared to each other. This comparison is less easy to make by means of multiple regression analysis in the case of more than one dependent variable.

Data analysis

It was investigated whether data of a questionnaire study among lorry drivers provided an acceptable fit to an important part of the model of Van Dijk et al. (1990), in which the working situation was related to health effects. The quality of model fit was considered to be satisfactory when the sample size was taken into account. According to the standardized solution of LISREL the lorry drivers' task contents made the most important contribution to the development of their health complaints, although the above-mentioned limitations in establishing causalities should be kept in mind. The relations between independent and dependent latent variables were widely ranged, which showed that the drivers were not divided into those who report no problems at all and notorious complainers.

The latent variable task contents was indicated by observed variables concerning the perceived difficulty with physical activities that the worker had to perform during loading and unloading (see Table 1). This latent variable was comparable to variables concerning perceived physical stressors in a study of Theorell et al. (1991), who also found that physical stressors were more strongly related to musculoskeletal complaints than psychological factors at work. Bigos et al. (1991) reported that the score on a scale concerning interpersonal relationships at work significantly predicted the report of back pain. Partly on the basis of the latter study, Bongers et al. (1993) stated that associations between (combinations of) low control and poor social support by colleagues (in this study low decision latitude and poor social relationships at work, respectively) and musculoskeletal complaints may be independent of increased perceived physical load. This could not be confirmed in the present study. Both variables showed the same pattern as other work-related psychosocial factors, i.e., the relations between these variables and musculoskeletal complaints disappeared when included in a multivariate model containing perceived physical load.

Significant effects on general psychosomatic complaints were found for task contents and terms of employment. This corresponds to the early study of Dirken (1967), who found that the VOEG was weakly correlated to perceived physical workload and variables concerning terms of employment. He reported about the same correlations for working conditions, but this was not found to be significant in the present study. According to Karasek and Theorell (1990), low decision latitude and low social support combined with high job demands may result in general psychosomatic complaints. However, the finding that social relationships at work and decision latitude were not related to these complaints should not be interpreted as conflicting with their theory, because interactions cannot be analyzed by LISREL. With respect to social relationships at work another explanation for the absence of a relation with complaints may be that driving simply prevents most of the lorry drivers from having frequent social contacts with other workers. This is supported by the finding of Hedberg et al. (1993) that a group of referents reported significantly more social support at work than professional drivers.

The present study would have been more valuable if the full model, rather than only an important part of it, could have been tested. However, short-term effects and work capacity are very difficult to assess in a reliable and valid way by means of a questionnaire. It is considered that the determination of these variables requires an extensive study at the workplace combined with simulations in the laboratory. It is recommended that in the future such studies be undertaken to obtain research confirmation for the full model.

Conclusions

Despite the above-mentioned shortcomings of this study, it can be concluded that the tested model ultimately provided an acceptable fit to the observed data of a questionnaire study among lorry drivers. The most important relation was found between work demands with respect to task contents (i.e., physical activities) and musculoskeletal complaints. It is recommended that in future occupational epidemiology, diverse aspects of the working situation are longitudinally related to health effects and not solely a single exposure variable.

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