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Original

Effects of Workplace Ergonomics on Productivity in an Offshore Oil Company

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Abstract

Background: The aim of this study is to investigate the relationship between the principles of ergonomics in both material and immaterial dimensions and employee productivity in (IOOC). **Methods:** Immaterial dimension of ergonomics was measured by variables such as freedom of activity at work and job feedback, and the material dimension of ergonomics was measured by factors such as workplace design and body position. The variables of the productivity construct based on the ACHIEVE model include ability, transparency, assistance, incentive, evaluation, credit, and environment. Each of the constructs was measured by an appropriate questionnaire filled out by 170 operational employees of the Company. Descriptive variables were analyzed using Structural Equation Modeling based on the PLS method to investigate the research hypotheses. **Results:** The level of employee productivity and ergonomics of the workplace in the IOOC are not desirable due to difficult working conditions and lack of managers' paying attention. The hypothesis of the effectiveness of ergonomics on productivity was confirmed and the material dimension was more effective on employee productivity than the immaterial dimension of human factors. **Conclusion:** Due to the difficult conditions of the operational units of oil companies, attention should be directed to the physical conditions of the work environment. To improve employee productivity, certain plans for human resource development and management, revision of the designing of the work environment, and work measurement are proposed.

Keywords: Ergonomics; Employee productivity; Iranian offshore oil company; Structural equation modeling

Introduction

Due to the increased complexity of the organization's structure, the organization of the work environment and the creation of a quiet and productive environment that leads to more active human resources, their happiness, reduced risks, increased quality of work, reduced depression, service growth and ultimately achievement of productivity, have become more important.

Human resource management shows that the development of productive human resources directly plays an important role in achieving many organizational goals.[1] A good environment can affect the growth of personal values and increase their capacity and productivity. Therefore, the science of human resource management and the provision of appropriate working conditions for leaders and managers of the organization is very important.[2] One of the most important ways to improve occupational

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health and improve the performance of employees in the workplace is to know the principles of ergonomics and the application of those principles in the design of occupational positions.

The most obvious positive effect of correctly and appropriately designing occupations, work equipment, and the environment is increased safety, health, adapting job to the employee, and ultimately job satisfaction and improved productivity.[3] Several studies have investigated the effects of human factor engineering on employee productivity. Abarqhouei et al. (2012) observed that the use of micro and macro ergonomics has a positive effect on the increase of employees' innovation and motivation, and the codification of programs to reduce the musculoskeletal problems of employees improves their efficiency.[4] The significant relationship between the physical conditions of the work environment and its dimensions (physical load, mental load, effort, performance and time load) to increase in employee productivity has been confirmed.[5] Haboubi et al. (2017) studied the effect of stress and job satisfaction on employee productivity in petrochemical industries, and reported there was no relationship between stress and productivity, but the relationship between job satisfaction and productivity was significant.[6] The study of Kumar and Loganten (2016) also found that factors such as carrying heavy objects, working under hot conditions, exposure to certain materials, work injuries, work more than 8 hours a day, working in a constant condition for a long time, and equipment vibration as the most important ergonomic factors effective on employee productivity.[7]

Sumarningsih et al. (2016) reported that the use of ergonomic principles in working methods of construction projects would increase employee productivity.[8] The purpose of this study is to measure the level of productivity variables and different dimensions of ergonomics in the Iranian Offshore Oil Company (IOOC) operation unit with a relatively difficult work environment. The application of two different aspects of ergonomics and emphasis on mental and emotional issues in the work environment were also studied. The results of this research can also help correct productivity improvement programs in the company under purpose.

Methods

The study population of this research consists of operational staff (of the Renovation-Repair Unit) of the IOOC. The company has a significant share of Iran's oil production. After designing a conceptual research model, appropriate questionnaires were designed for each of the structures. The questionnaires were randomly distributed among 170 operational staff of the IOOC who were selected by cluster sampling in 2016-2017. In addition to the descriptive analysis of data and determining the status of the work environment and employee productivity in the case study, partial least square was used to investigate the research hypotheses.

The dependent variable of the present study was employee productivity. The conceptual model of the research includes predictor and dependent variables Figure 1.

As illustrated in this Figure, each of the main variables has different dimensions, whose measurement is to measure the level of the latent variables. Dimensions of the latent variables of immaterial factors include freedom of action in work, job feedback, diversity, identity and importance of duties, overload, training and promotion, and organizational commitment. The material dimensions of ergonomics also include 17 dimensions specialization in work, necessary skills, physical activity, manual displacement, workplace design, a physical position at work, sound, weather conditions, lighting, dust and toxic materials, vibration, work schedules, monitors, controls, machinery, small and safety instruments and tools. The standard questionnaire was used to measure each of the dimensions of the factors mentioned in the conceptual model of the research.

Each dimension was measured by direct questions with standard questionnaires. To measure the

dimensions of physical and nonmaterial ergonomic factors, standard questionnaires of the Center for Health and Environment[9], which consisted of 85 and 31 questions, were used. The ACHIEVE, proposed by Hersey and Goldsmith[10] and containing 26 questions, was used to measure the level of productivity.

All items were rated on a 7-point Likert scale (from very high to very low). In addition to items on the dimensions of the conceptual model of the research, participants were also asked to answer questions about demographic characteristics such as age, education, etc. To assess the reliability of the questionnaire, 30 questionnaires were first distributed to the study population and then, by calculating the Cronbach's alpha coefficient, the reliability of the questionnaire was evaluated. Cronbach's alpha coefficient for all constructs was over 70%.

Statistical analysis

In the present study, the data obtained from the questionnaires were analyzed using descriptive and inferential statistics. A descriptive analysis of frequency distribution tables is used to investigate and analyze research data and variables. To investigate the research hypotheses and generally to test the conceptual model of research (Fig. 1), based on the collected data, the partial least squares (PLS) that are a variance-driven modeling technique and allows us to examine hypotheses (the relationship between latent and obvious variables) simultaneously, is used. The PLS is one of Structural Equation Model (SEM) approaches and is a method for the analysis of developmental and reflective constructs[11], and a comprehensive approach to testing assumptions about the relationships of observed and latent variables, especially when the number of indicators of each factor is high and there is collinearity between them. In designing the structural model of the present study, this approach is used to estimate factor loadings and path coefficients.

One of the strengths of the PLS, as one of the SEM techniques, is its ability to analyze very complex models and estimate the coefficients of the variables' effects even when the sample size is small and the distribution is not normal.[12, 13] Therefore, due to the small size of the sample collected for this research, as well as the latent variables in the model, and the need to examine the hypotheses and validate the model, the PLS method is appropriate and has a high fit with the existing conditions. Generally, the PLS method consists of two parts, namely, the measurement model and the structural model. The variables of the model are divided into two groups, namely latent and obvious.

Latent variables or structures such as variables of productivity, material and immaterial dimensions of ergonomics are variables that are not directly measurable and measure them using obvious variables (questionnaire questions). In the measurement model, the relationship between questions and latent variables (structures) is analyzed. In the structural model, the correlation between the constructs and the relationships between them are focused. Reliability indices for estimating the internal consistency of constructs were three factors: coefficient of the factor loading, Cronbach's alpha, and composite reliability. Convergent validity indicates the correlation of a construct with its indices and the divergent validity does the level of relationship of a construct to its indices compared to its relationship with other constructs. After evaluating the measurement models, indices such as the coefficient of determination were used to examine the model's fitness with the data. In the case of acceptable fitness of the model, the relationship between constructs can be investigated.

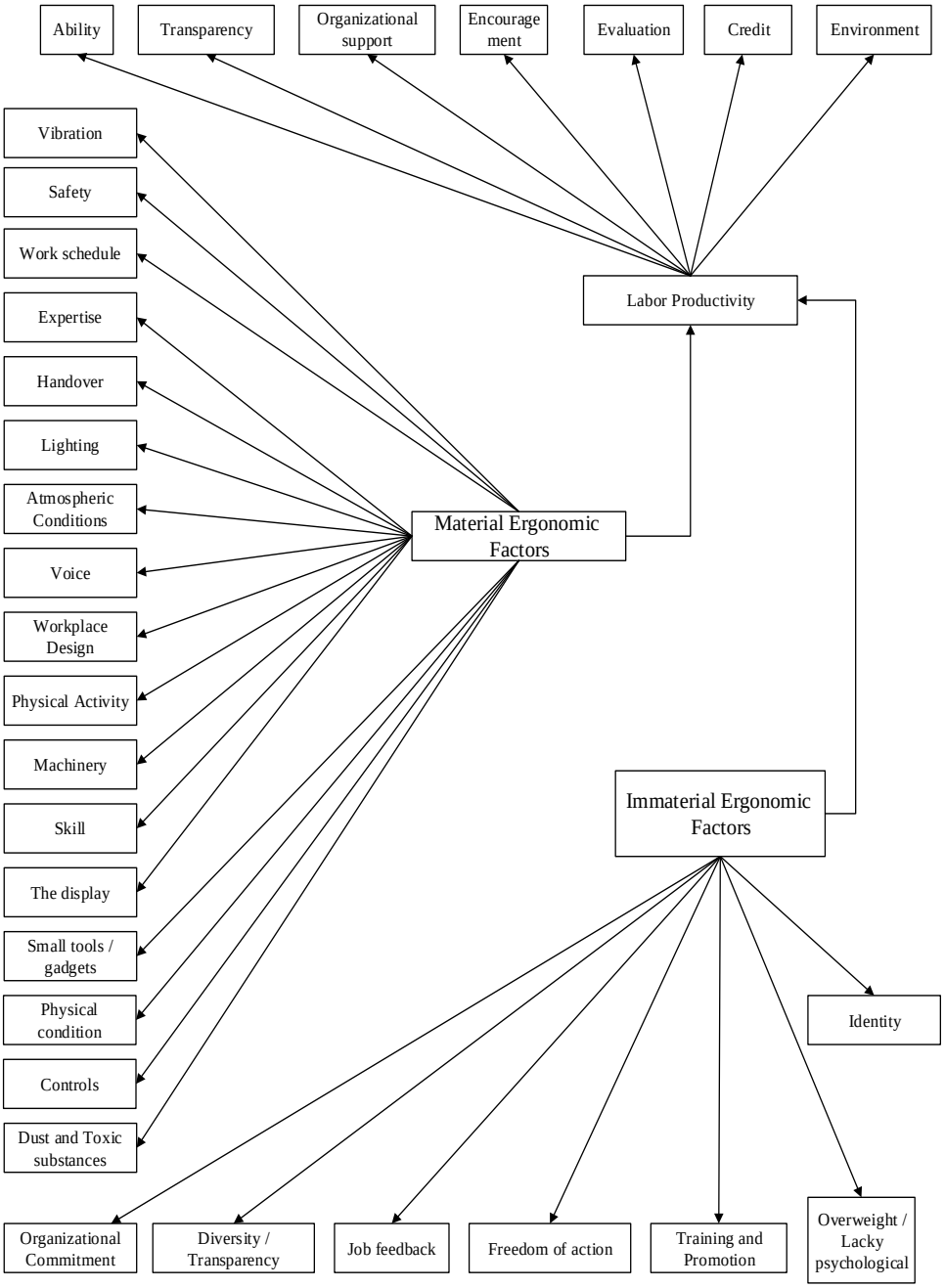

Figure 1. The conceptual model of research

Results

Because of the nature of the study population, all participants are male. 62% of respondents aged less than 40 and 67% had a bachelor's degree and master's degree. Besides, 70% of respondents had a work experience of over 10 years Table 1.

Table 1. Summary of descriptive statistics of studied demographic characteristics

Variable	Categories	Percentage	Variable	Categories	Percentage
Age (yr)	20-30	14	Work history (yr)	Less than 5	6
	30-40	48		5-10	24
	40-50	29		10-20	49
	50 and over	9		Over 20	21
Education level	High school diploma	15	Work schedule	Day shiftwork	52
	Associate's degree	18		Night shiftwork	2
	Bachelor's degree	37		Rotational shiftwork	46
	Master's degree	30			
Marital status	Single	14	Exercise program	Yes	54
	Married	86		No	46
History of physical disease	Yes	16	History of mental disease	Yes	6
	No	84		No	94

Table 2. Descriptive statistics of demographic variables

Construct	Variable	Mean	Significance level	Construct	Variable	Mean	Significance level
Material dimension of ergonomics	Specialty at work	2.28	0.00	Immaterial aspect of ergonomics	Freedom of action at work	2.90	0.08
	Necessary skills	2.26	0.00		Job feedback	2.00	0.00
	Physical activity	2.28	0.00		Diversity	2.41	0.00
	Manual displacement	2.25	0.00		The identity and importance	2.23	0.00
	Workplace design	2.18	0.00		Overload	2.23	0.00
	Physical positioning	1.99	0.00		Training and promotion	2.05	0.00
	Noise	2.24	0.00		Organizational commitment	3.29	1.000
	Weather conditions	2.10	0.00		Ability	2.45	0.00
	Lighting	2.23	0.00		Transparency	2.27	0.00
	Dust and toxic substances	2.00	0.00		Organizational support	2.31	0.00
	Vibration	2.10	0.00	Productivity	Encouragement	2.18	0.00
	Work schedule	2.10	0.00		Assessment	2.18	0.00
	Monitor	2.30	0.00		Credit	2.21	0.00
	Controls	2.90	0.00		Environment	2.17	0.00
	Machinery	2.55	0.00				
	small tool/instruments	2.25	0.00				
	Safety	2.63	0.00				

Table 3. The criteria of Cronbach's alpha, composite reliability and convergent validity

Latent variables	(Alpha ≥ 0/7)	(CR ≥ 0/7)	(AVE ≥ 0/5)
Material dimension of ergonomics	0.97	0.98	0.71
Non-material dimension of ergonomics	0.89	0.89	0.59
Productivity	0.89	0.97	0.60

Table 2 shows the mean scores for each of the model's variables. As seen, the average value of each variable is lower than the average level the average of all scores of the questions related to the material dimension of ergonomics, non-material dimension of ergonomics, and the amount of productivity was estimated at 2.25, 2.51 and 2.25, respectively. Accordingly, in the operational unit of the IOOC, the ergonomics of the work environment and productivity were estimated at a lower than average level.

Results of the measurement model

The coefficients of factor loadings are calculated by calculating the correlation between the obvious variables of a construct with that construct and its acceptable value is 0.4 and over.[11] The factor loadings resulting from the implementation of the model for each variable are illustrated in Fig. 2.

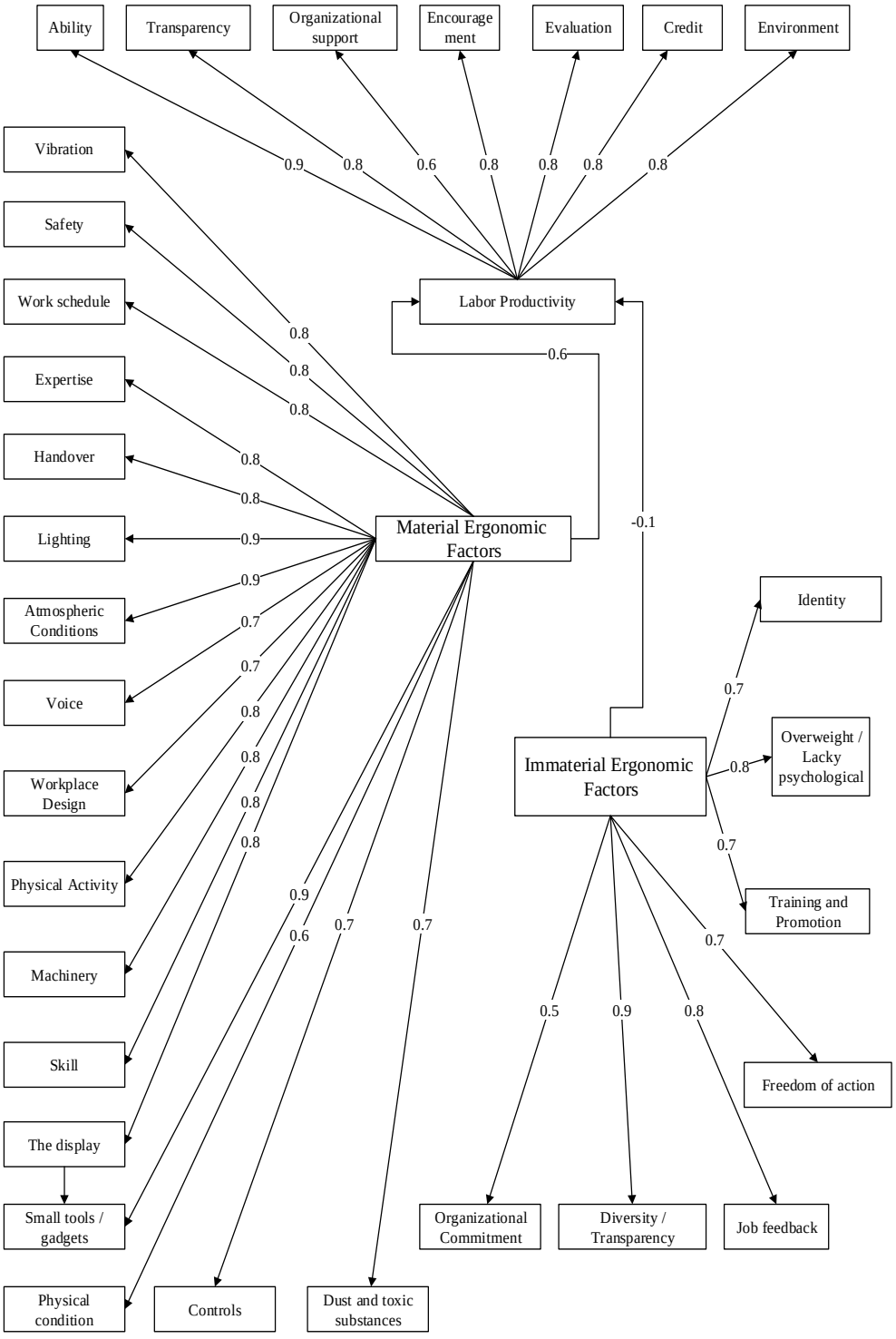

Figure 2. Curve and path coefficients

Table 4. Test of research hypotheses

Independent variable	Effect	Dependent variable	Path coefficient	*P* value
Ergonomics	←	Productivity	0.69	0.00
Material dimension of ergonomics	←	Productivity	0.65	0.00
Non-material dimension of ergonomics	←	Productivity	0.10	0.035

In this analysis, no measure with factor loading lower than the standard (0.4) was observed. Therefore, all measures remain in place, and obvious variables have adequate accuracy to measure constructs or latent variable in order to investigate the reliability, the Cronbach's alpha coefficient and the coefficient of reliability (CR) were calculated (Table 3). In order to evaluate the divergent validity of the measurement model, Fornell and Larcker criterion was used. Based on this criterion, an acceptable divergent validity of a model suggests that a construct in the model interacts more closely with its indexes than other structures. The correlation coefficient of the two material and immaterial dimension with the productivity construct was estimated to be 0.69 and 0.33, respectively, and the correlation coefficient of the two independent constructs in the conceptual model was 0.35. The significance of these coefficients also confirms the measurement models in the SEM of this study.

Results of the structural model

The coefficient of determination for the regression model of the research structures was estimated to be 48%, which indicates the model's acceptable fit on the data. In order to examine the predictive power of the model, the Q2 (Stone-Geisser criterion) criterion was used. Henseles et al. (2009) have suggested that the prediction power of the model for endogenous structures is 0.02, 0.15 and 0.35 for weak, moderate, and strong prediction power, respectively.[15] The value of this indicator for the proposed model in this study was estimated at 0.46, and it can be argued that it represents the predictive power of a strong model.

The results regarding the coefficients of the regression model of the research constructs and their significance based on the research hypotheses are presented in Table 4. As clearly seen, both hypotheses of the effects of material and immaterial dimensions of ergonomics on employee productivity were confirmed. However, the impact of the ergonomics material dimension on employee productivity is greater than that of ergonomics immaterial dimension. In addition to the main conceptual model of the research, a secondary model was developed, in which one constructs, instead of two ergonomic constructs, was included. The study of this model also showed that in general, the conditions of the work environment, both in terms of material dimension and immaterial, affected employee productivity.

Discussion

The results of this study showed that the ergonomics of the work environment have a positive and significant effect on the productivity of the operational employees of the IOOC who work in an undesirable environment and under difficult conditions. In addition, both material and immaterial dimensions of ergonomics have a significant effect on employee productivity, but the effect of the material dimension is greater than that of the immaterial dimension of ergonomics. Other studies have also reported such findings, including the studies of Sumarningsih et al.[8] Kumar and Logant[7], Sanders[16], Hosseini and Mehdizadeh[17], and Nikpour and Zare Kaseb.[18]

The results of this study show that immaterial variables of ergonomics have less effect on employee productivity. In the current study, the effects of immaterial factors of ergonomics, namely freedom of action in the workplace, job feedback, diversity and transparency of work, identity and importance of duties, overload, training and promotion, and organizational commitment, on employee productivity were investigated. The results of the present study are incompatible with the results of the studies of Heydarian[19] and Sanders [16] with respect to the effect of the freedom of action in the workplace on employee productivity.

It seems that lack of ways to expand the culture of freedom of action at work, such as creating the culture of eliciting the viewpoints of professionals and employees, giving importance to the initiative in employee performance, etc., within the legal

conditions of the organization, is the reason for this inconsistency. The results of this study regarding the effects of job feedback on productivity are not consistent with the results of Kaseb, Dunlop and Wil[20] and Barthel.[21] The lack of an appropriate employee evaluation system can explain this finding.

The results of this study regarding the effects of job diversity and transparency on employee productivity are not consistent with the results of Antikainen et al.[22] Robinson[23] and Drucker[24]. The existence of methods to do traditional, non-scientific, and empirical work in the company can explain this finding. The results of the present study regarding the effect of overload on employee productivity are not consistent with the results of Vink et al.[25] and Bailey[26]. The reason for the rejection of this hypothesis is that the type of work is not eroding, appropriate conditions of the work environment, the mechanization of tasks, and the hiring of expert and experienced forces. The results of this study on the effect of education and promotion on employee productivity are not in agreement with the results of Vink et al.[25]

The reason for the rejection of this hypothesis is the lack of an appropriate structure or inappropriate structure of the company in the areas of payment and salary, occupational security, disability and punishment, and having a favorable work environment (such as teamwork, autonomous teams, direct relationship with the manager).In addition, confirmation of the effects of the material dimension of ergonomics on employee productivity is logical due to the hard working conditions of the IOOC. The results of this hypothesis on environmental conditions are consistent with the results of Lee et al.[28] Moosavipour and Jahangirfard[29], and Heidarian.[19] The results of this hypothesis regarding the design of the work environment are consistent with the results of Zakarian et al.[30] The results of this hypothesis regarding the physical activity and manual displacement are in agreement with the results of the kadkhodaei and Seyedi.[5] The results of this hypothesis regarding the effects of lighting and vibration are consistent with the results of Moosavipour and Jahangirfard.[29]

The failure to measure the productivity indicators of human resources in this study, which directly measures the productivity of human resources and the lack of access to the views of the employees in other operational units in this company, are among the limitations of this research. The fact that the employees of the Renovation and Repair Unit of the IOOC work in difficult environmental conditions in terms of the ergonomics, and because of their physical work and distance, have weaker relationships with other people can sensibly explain the results of statistical analyses.

Conclusion

Working in difficult conditions is one of the potential factors that affect employee productivity. Since ergonomics involves two dimensions, material and immaterial, knowing the impact of each of these dimensions on productivity will improve programs for improving employee productivity. The hypothesis of ergonomics effectiveness on productivity was confirmed in this study and the material dimension was found to be more effective than the immaterial dimension on employee productivity. Due to the difficult working conditions of the operational units oil companies, paying attention to the physical conditions of the work environment is essential. To improve employee productivity, certain plans for human resource development and management, revision of the designing of the work environment, and work measurement are proposed.

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