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Validity, Sensitivity, and Reliability Testing by Ergonomic Evaluation Methods for Geothermal Task

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ABSTRACT

The purpose of this research is to test and evaluate the validity, sensitivity, and reliability of QEC, RULA, REBA, and Strain Index methods in geothermal tasks for an Indonesian worker. Validity tests are based on Force Compression (Fc) values—a kind of geothermal task using 3DSSPP software—and seeing the correlation with QEC, RULA, REBA, and Strain Index using a Spearman test. Sensitivity Tests are based on evaluation methods that have shown correlation in a validation test. After that, one-way Analysis of Variance (Anova) is based on the post-hoc tukey method. Reliability tests are based on appraisal tasks by 10 respondents to get the Intraclass Correlation Coefficient (ICC) value.

The test results show:

The validity test is based on the occupational biomechanical (L5/S1); the value of Fc using software 3DSSPP is dominant task element (Fc_1), validated with dominant task element strain index method (SI_1) and risk (SI_2). Risk task element (Fc_2) is validated with dominant task element I (SI_1), risk task element RULA ($RULA_2$), and risk task element REBA ($REBA_2$).

The sensitivity test results are based on methods that have been validated using group base Fc; one-way Anova is SI method (SI_2) for dominant task element and REBA ($REBA_2$) for risk task element.

The reliability test results are based on the ICC value; all methods have high reliability.

1. INTRODUCTION

Geothermal has a high risk of work-related accidents. According to report of National Institute for Occupational Safety and Health (NIOSH, 1981), about 500 workers in United States of America suffer injury that is caused by overexertion every year. Two kinds of injury are Low Back Pain (LBP) and Upper-Extrimity Cumulative Trauma Disorders (UECTDs). Work accidents happen because of ergonomic problems. The concept that first focused on ergonomics is occupational biomechanical.

Work assessments in geothermal need tools for ergonomic assessment that are simple, quick, and flexible to use. Ergonomic evaluations that have been used in many countries—and potentially applied in Indonesia—are Quick Exposure Check (QEC), Rapid Upper Limb Assessment (RULA), Rapid Entire Body Assessment (REBA), and Strain Index (SI).

The purpose of this study is to test and evaluate the validity, sensitivity, and reliability of QEC, RULA, REBA, and Strain Index methods in geothermal tasks for an Indonesian worker. This is needed because there has been no further research on the subject.

2. METHODS

The study was conducted on geothermal activity. Based on a survey collected by Nordic Questionnaire and interviews with the workers, 8 jobs were selected to be investigated: Welding, Water Sampling, Lubricator Installation, Kuster Installation, Opening and Closing Valve, Monitoring barthon chart, monitoring H_2S, and mixing cement. These eight jobs are divided into two task elements: dominant task and risky task. Dominant task is the job element that is often done on the type of work and risky task is the job element that tends to lead to injury on the job and requires a lot of energy during the work (Bao, et all, 2008).

2.1 Participant

For each of the eight jobs, three workers were involved. Therefore, a total of twenty four workers (all males, age 19-45 years old) were involved in this study. For the reliability test, ten respondents were involved. These respondents were workers in PGE Kamojang; their level of knowledge about QEC, RULA, REBA, and Strain Index was variable.

2.2 Procedures

2.2.1 Validity Testing

Validity testing is based on the value of the compression force (Fc), eight types of geothermal activity using 3DSSPP software, and seeing the correlation to QEC, RULA, REBA, and Strain Index using the Spearman test. Spearman correlation is the r sample correlation to measure the linear relationship between two continuous variables X and Y by Walpole (1995).

$$r_p = 1 - \frac{6\sum_{i=1}^{n} di^2}{n(n^2 - 1)} \qquad (1)$$

$$t_{observed} = r_p \sqrt{\frac{n-2}{1-r_p^2}} \qquad (2)$$

2.2.2 Sensitivity Testing

Sensitivity Testing is conducted by evaluating the sensitivity of the methods that are valid (correlated) on the validity test. Eight task types were grouped using one-way ANOVA by Tukey post-hoc method.

2.2.3 Reliability Testing

Reliability testing is conducted by assessing the eight types of geothermal jobs using ten respondents to get the value of intraclass correlation coefficient (ICC) in accordance with Denager and Ball (1993). ICC values were between 0-1; the closer the value to 1 then the higher the level of reliability. Tests were carried out 2 times, with the second test performed 2 days after the first test. Each respondent conducted QEC, RULA, REBA, and strains index assessment for each task element. Reliability testing was conducted at the HSE meeting room using a laptop and projector to show the video of workers; a table was used to hold the laptop; chairs were used as seats for respondents; and assessment sheets were used. Before conducting the assessment, the respondents were given 30 minutes of assessment training by the researchers. After completion of training, the respondents conducted the assessment; the longest assessment is 175 minutes with a 15 minutes break.

$$ICC = \frac{BMS - TMS}{BMS + (k-1)EMS + k\left[\frac{TMS - EMS}{N}\right]} \qquad (3)$$

3. RESULT

3.1 Validity Testing

Table 1 shows 3DSSPP, QEC, RULA, REBA, and Strain Index values for each task. Point 1 means dominant task and point 2 means risky task.

Table 1. Data Summary

Task	$3DSSPP_1$	$3DSSPP_2$	QEC_1	QEC_2	$RULA_1$	$RULA_2$	$REBA_1$	$REBA_2$	SI_1	SI_2
1	1633	1633	49.38	49.38	6	6	10	10	10.13	10.13
2	1182	1182	35.8	35.8	4	4	10	10	7.59	7.59
3	1827	2257	51.14	53.41	5	9	11	12	27	36
4	1543	1923	43.21	34.57	5	6	10	12	15.19	27
5	1682	2263	53.41	58.02	5	7	7	11	9	9
6	1199	1332	38.27	43.21	7	7	6	9	9	10.13
7	494	494	53.09	53.09	4	4	4	4	0.8	0.8
8	1814	1814	79	79	5	5	9	9	10.13	10.13

The correlation between Fc L5/S1 with ergonomics evaluation method that QEC, RULA, REBA, and SI both dominant and risk tasks by looking at significant level with the Spearman test shown table 2.

Table 2. Correlation Summary

3DSSPP	Method	rp	t Observe	t Table	Summary
$3DSSPP_1$	QEC_1	0.524	1.740	2.447	Accepted HO
$3DSSPP_1$	QEC_2	0.619	2.229	2.447	Accepted HO
$3DSSPP_1$	$RULA_1$	0.358	1.084	2.447	Accepted HO
$3DSSPP_1$	$RULA_2$	0.643	2.375	2.447	Accepted HO
$3DSSPP_1$	$REBA_1$	0.512	1.686	2.447	Accepted HO
$3DSSPP_1$	$REBA_2$	0.521	1.726	2.447	Accepted HO
$3DSSPP_1$	SI_1	0.783	3.560	2.447	Rejected HO
$3DSSPP_1$	SI_2	0.683	2.645	2.447	Rejected HO
$3DSSPP_2$	QEC_1	0.405	1.253	2.447	Accepted HO
$3DSSPP_2$	QEC_2	0.381	1.166	2.447	Accepted HO
$3DSSPP_2$	$RULA_1$	0.294	0.870	2.447	Accepted HO
$3DSSPP_2$	$RULA_2$	0.727	2.995	2.447	Rejected HO
$3DSSPP_2$	$REBA_1$	0.415	1.290	2.447	Accepted HO
$3DSSPP_2$	$REBA_2$	0.764	3.349	2.447	Rejected HO
$3DSSPP_2$	SI_1	0.699	2.765	2.447	Rejected HO
$3DSSPP_2$	SI_2	0.61	2.177	2.447	Accepted HO

From table 2 above Fc_1 not significantly different from SI_1 and SI_2 while Fc_2 not significantly different from $RULA_2$. $REBA_2$, and SI_1.

3.2 Sensitivity Testing

Fc_1 is not significantly different from SI_1 and SI_2, while Fc_2 is not significantly different from $RULA_2$. $REBA_2$, and SI_1.

Table 3. Dominant Task Sensitivity Summary

Method	Task Group	F	Summary
$3DSSPP_1$	(1),(2.6),(1.4.5),(3.8)	177.145	
SI_1	(1,2,4,5,6,8), (3), (7)	55.265	
SI_2	(1,2,5,6,8), (3,4), (7)	88.929	More Sensitive

Based on the grouping, SI_2 is more sensitive shown in table 3.

Table 4. Risky Task Sensitivity Summary

Method	Task Group	F	Summary
$3DSSPP_2$	(7), (2,6), (1,8), (4), (3.5)	266.365	
SI_1	(1,2,4,5,6,8), (3), (7)	55.265	
$RULA_2$	(1,4,6), (2,7,8), (3,5)	20.309	
$REBA_2$	(1,2,3,4,5), (6,8), (7)	58.875	More Sensitive

Based on the grouping, $REBA_2$ is more sensitive shown in table 4.

3.3 Reliability Testing

The results of reliability testing based on the value of the ICC are all methods have high reliability shown at table 5.

Table 5. ICC Values Summary

Task	Factor	ICC	Summary
1	QEC_1	0.872	High Reliability
2	QEC_2	0.868	High Reliability
3	$RULA_1$	0.611	High Reliability
4	$RULA_2$	0.72	High Reliability
5	$REBA_1$	0.907	High Reliability
6	$REBA_2$	0.864	High Reliability
7	SI_1	0.674	High Reliability
8	SI_2	0.901	High Reliability

4. ANALYSIS

For validity testing, Fc_1 was obtained and correlated (not significantly different) with SI_1 and SI_2; Fc_2 is not significantly different from $RULA_2$. $REBA_2$, and SI_1. The value of the Correlation Coefficient Fc_1 from SI_1 and SI_2 is 0.783 and 0.683, whereas the value of Correlation Coefficient Fc_1 from QEC_1, QEC_2, $RULA_1$, $RULA_2$, $REBA_1$, and $REBA_2$ is 0.524, 0.619, 0.358, 0.643, 0.512, and 0.521; all of them have significant level smaller then SI_1 and SI_2. This happened because of differences in the rank sequence of Fc_1. These methods produce relatively large variation, so the significance is relatively small.

5. DISCUSSION

There is a high variation in application of ergonomic evaluation methods. Therefore, one must choose which method is appropriate for measuring a job. To measure the work, especially work that uses the dominant hand movements, one should use the Strain Index. This method is more sensitive than other methods used. Measurement of risk elements should use REBA method, since REBA is more sensitive than other methods.

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