

The effect of wearable safety technologies on worker safety and project timelines

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chapter four: Statistical analysis of the study results

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1.1 Introduction:

This chapter presents the findings from the field study, analyzed using the statistical software SPSS version 28. The chapter is systematically organized to cover the key components of the statistical analysis conducted.

First, the **characteristics of the study sample** are detailed, providing an overview of the demographic and other relevant features of the participants. This section uses descriptive statistics to offer a clear understanding of the sample under investigation.

Next, the chapter evaluates the **validity and reliability of the research tool** employed in the study. SPSS version 28 was used to ensure that the questionnaires were both accurate and consistent in measuring the intended variables, thereby validating the data collected.

Following this, a **descriptive analysis of the study variables** is conducted. This analysis provides insights into the central tendencies, distributions, and other key statistical measures related to the variables under study, setting the stage for deeper analysis.

To examine the relationships between the variables, **linear correlation coefficients** are calculated. This step allows for an understanding of how the study variables are related, which is critical for testing the study's hypotheses.

The chapter then proceeds to the **results of testing the validity of the study hypotheses**. Using simple linear regression analysis conducted through SPSS version 28, the study's hypotheses were rigorously tested to determine their validity and to assess the suitability of the proposed model.

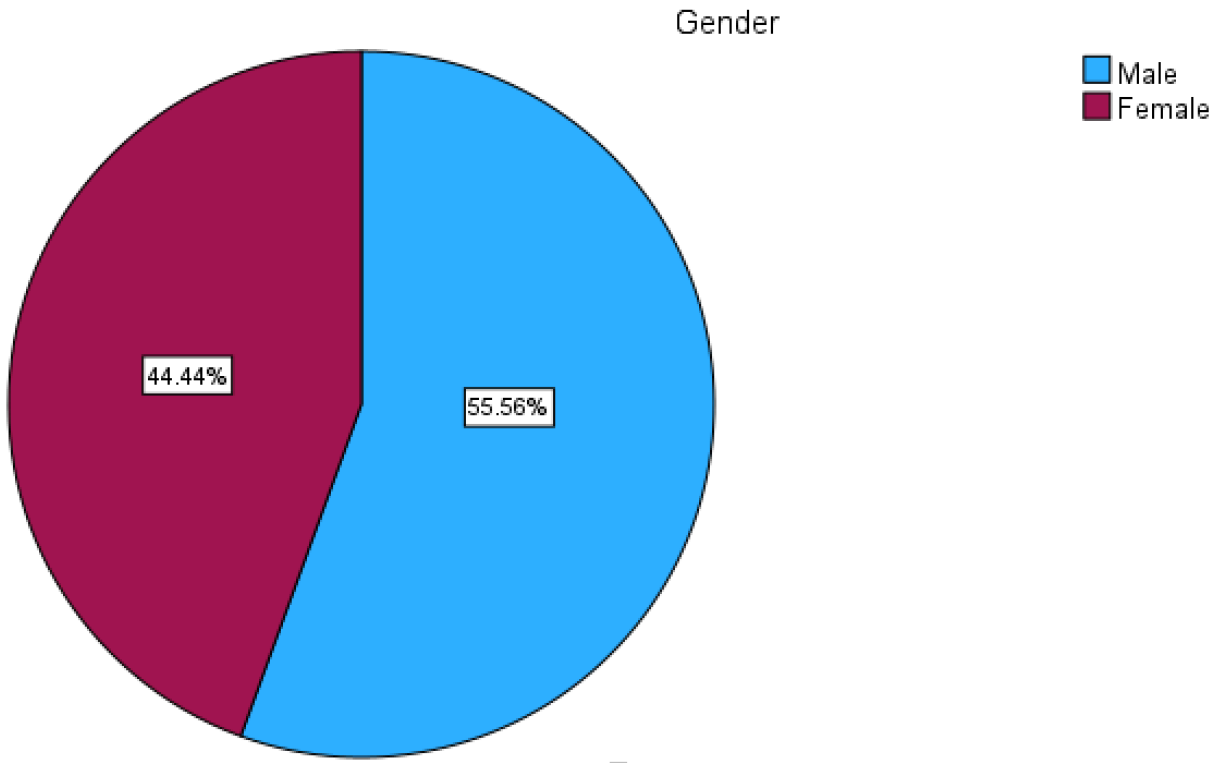
Finally, the chapter concludes with a summary of the findings, offering key insights and implications derived from the analysis.

4.2 Characteristics of the study sample:

The study sample, consisting of 54 individuals, was categorized based on gender, age group, educational level, and their relationship to on-site jobs. Frequencies and percentages were calculated for each demographic category, which are detailed as follows:

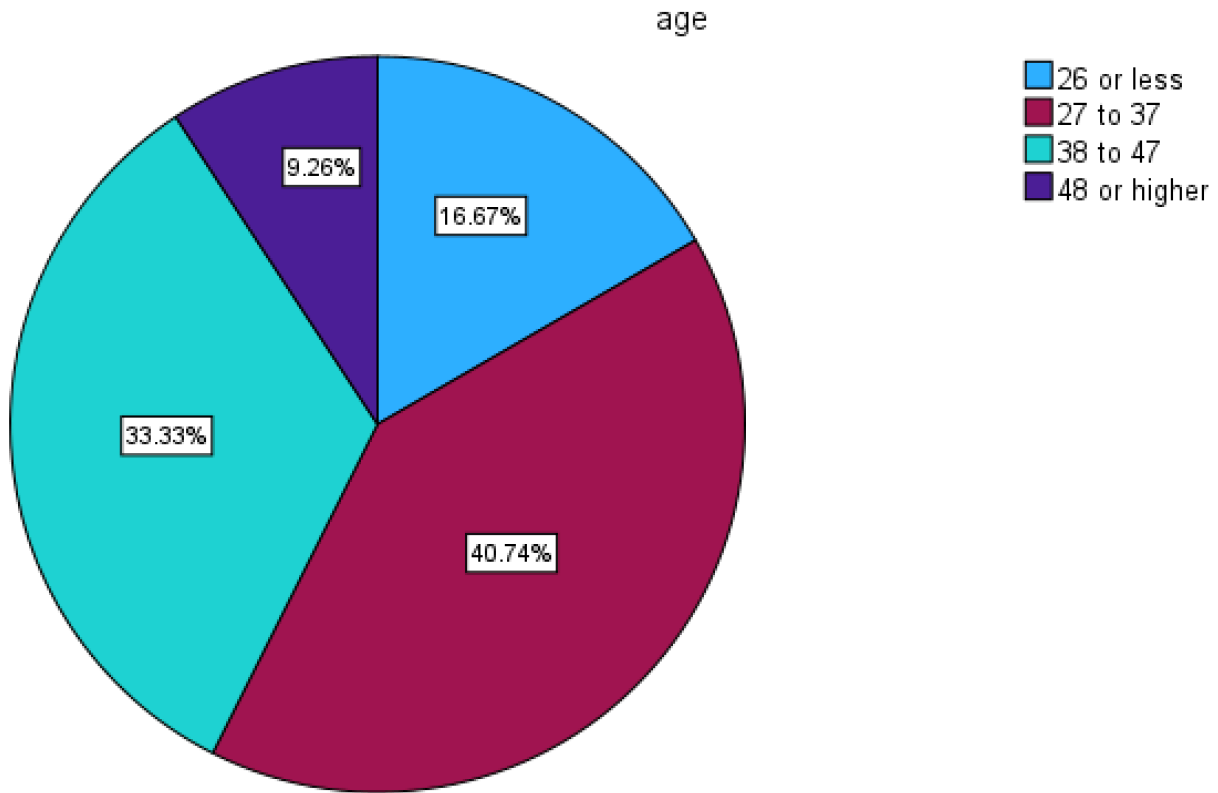
- **Gender:** The sample includes both males and females.
- **Age Group:** The participants are divided into the following age categories: 26 or younger, 27 to 37, 38 to 47, and 48 or older.
- **Educational Level:** The educational background of the participants includes Associate, Diploma, Bachelor's, Master's, and Ph.D. degrees.
- **Nature of Work:** Participants were asked whether their work is related to construction or operational sites (Yes/No).

Variable	Variable classes	The number	Percentage of the total sample
Gender	Male	30	55.56%
	Female	24	44.44%
	Total	54	100%
The age group	26 or less	9	16.67%
	27 to 37	22	40.74%
	38 to 47	18	33.33%
	48 or higher	5	9.26%
	Total	54	100%
Educational Level	Associate	7	12.96%
	Diploma	21	38.89%
	Bachelor	21	38.89%
	Master	3	5.56%
	Ph.D.	2	3.70%
	Total	54	100%
Construction / operational site	Yes	34	62.96%
	No	20	37.04%
	Total	54	100%



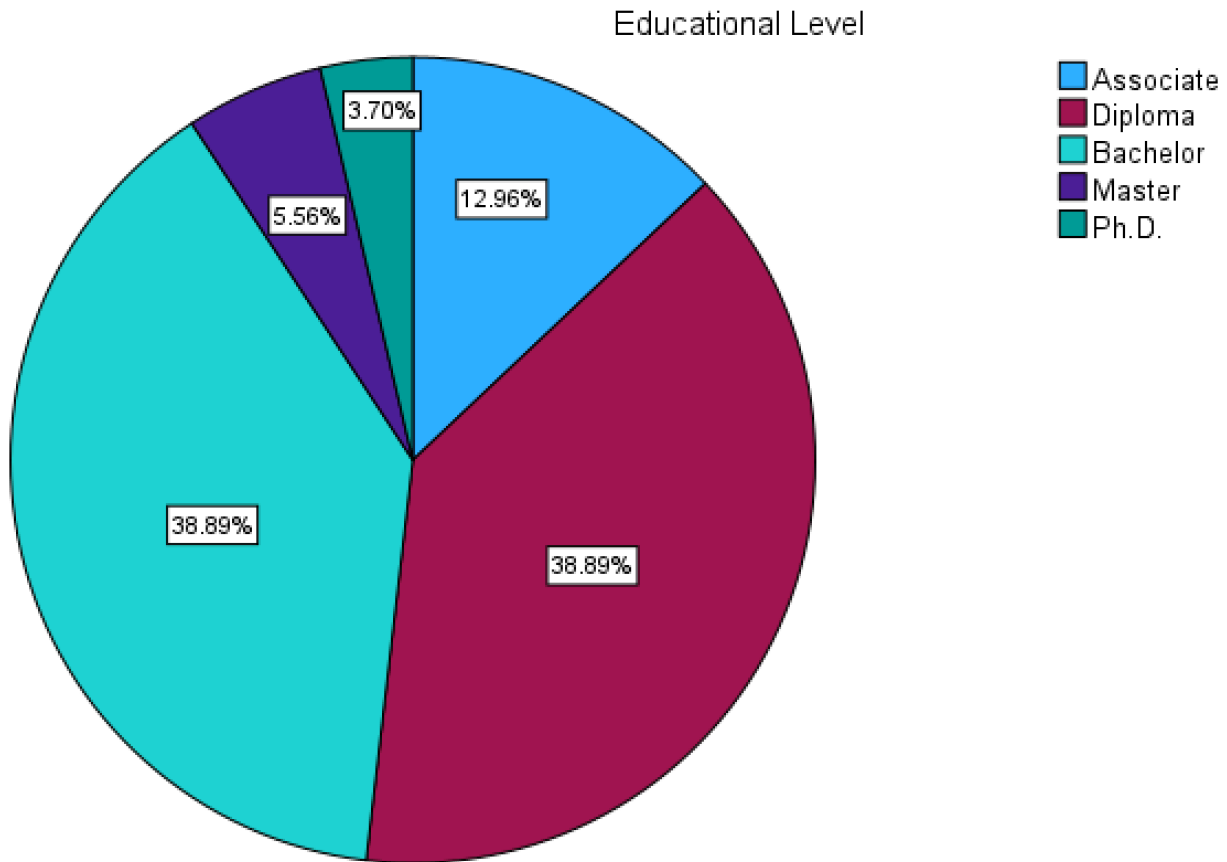
Gender Distribution of the Study Sample

The pie chart illustrates the distribution of the study sample by gender. The study included a total of 54 participants. Out of these, 55.56% were male, while 44.44% were female. This summary provides an overview of the gender composition, including the number of responses and their respective percentages of the total sample.



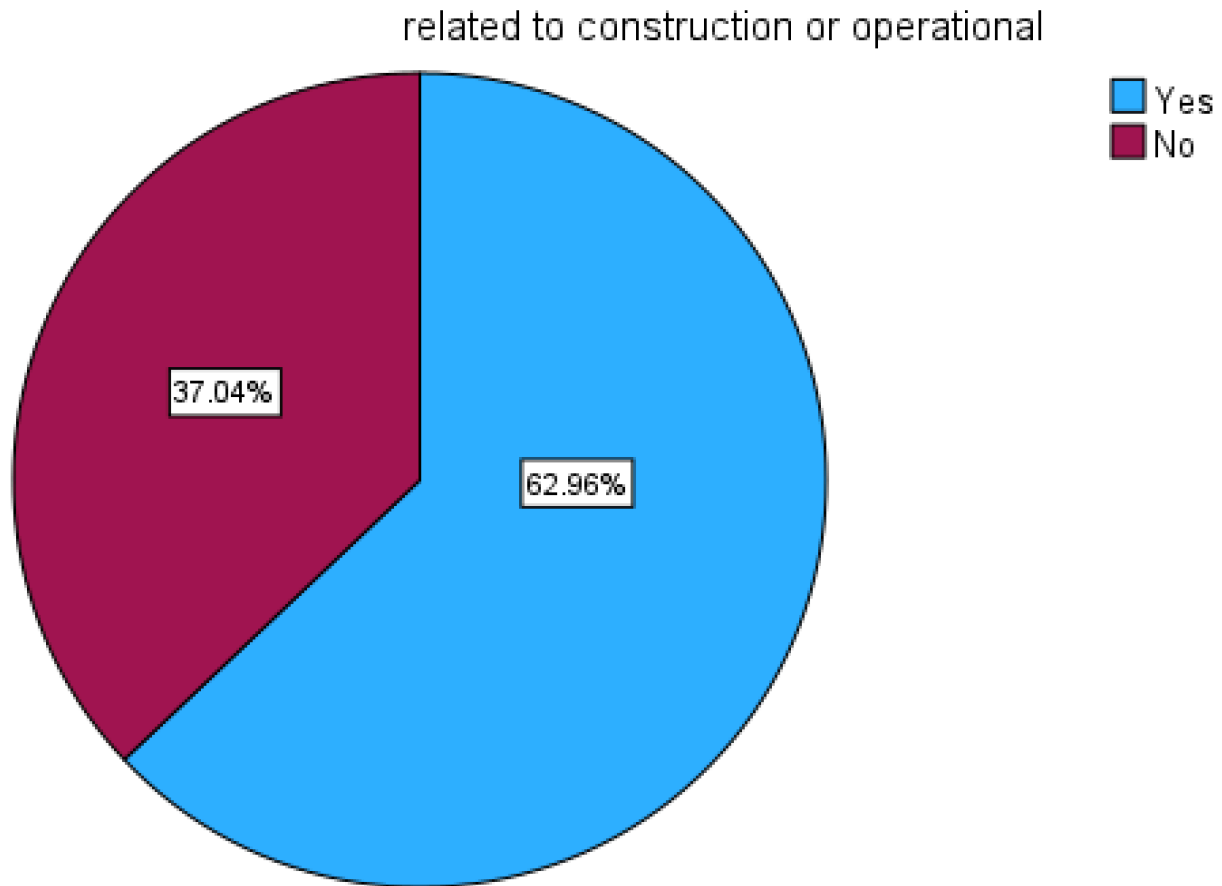
Age Distribution of the Study Sample

The pie chart illustrates the age distribution of the study sample, which consists of 54 participants. The age groups are categorized as follows: 16.67% of the participants are 26 years old or younger, 40.74% fall within the age range of 27 to 37 years, 33.33% are aged 38 to 47 years, and 9.26% are 48 years or older. This summary provides a clear overview of the age categories, the number of responses within each group, and their respective percentages of the total sample.



Educational Level Distribution of the Study Sample

The pie chart illustrates the educational level distribution of the study sample, which consists of 54 participants. The educational levels are categorized as follows: 12.96% of the participants hold an Associate degree, 38.89% have a Diploma, 38.89% have a Bachelor's degree, 5.56% hold a Master's degree, and 3.70% have a Ph.D. This summary provides a clear overview of the educational backgrounds within the sample, including the number of responses and their respective percentages of the total sample.



Relation to Construction or Operational Work

The pie chart illustrates the distribution of the study sample based on their relation to construction or operational work. Among the 54 participants, 62.96% indicated that their work is related to construction or operational activities, while 37.04% reported that their work is not related to these fields. This summary provides a clear overview of the participants' professional backgrounds, including the number of responses and their respective percentages of the total sample.

4.3 Measuring the Validity and Reliability of the Research Tool:

To ensure the validity and reliability of the research instruments used in this study, several statistical tests were conducted. The internal consistency validity of the questionnaires, which were designed to measure the study variables, was assessed using SPSS version 28. This involved testing the correlation between items within each construct to verify that they accurately reflect the same underlying concept.

Convergent validity was evaluated by calculating the Average Variance Extracted (AVE) for each construct. AVE measures the extent to which a construct explains the variance of its indicators, ensuring that the items are representative of the construct they are intended to measure.

The reliability of the study instruments was determined by calculating Cronbach's alpha for each construct. Cronbach's alpha is a measure of internal consistency that indicates how closely related a set of items are as a group. A high Cronbach's alpha value suggests that the items in the questionnaire are reliably measuring the intended constructs.

The following paragraphs and tables provide a detailed explanation of these tests, including the calculated values for internal consistency validity, AVE, and Cronbach's alpha. These analyses were performed using SPSS version 28 to ensure the robustness and accuracy of the results.

4.3.1 Validity of the Measures Used in the Study

The validity of the measures used in this study was assessed through two main approaches: internal consistency validity and convergent validity. These methods ensure that the scales used to measure the study variables are both reliable and accurate.

Internal Consistency Validity:

Internal consistency validity refers to the degree to which each item within a questionnaire is consistent with the variable it is intended to measure. To assess this, the researcher calculated the correlation coefficients between the score of each item and the total score of the variable to which it belongs. According to the study by Kaiser (1974), any item with a correlation coefficient of less than 0.5 was removed from the questionnaire, as it would not adequately represent the construct being measured.

Convergent Validity:

Convergent validity was measured by calculating the Average Variance Extracted (AVE), which assesses the average variance shared between items that measure the same construct. According to Hair et al. (2006), the AVE value should be greater than 0.5 to ensure that the items are adequately representing the construct.

The following tables present the statistical results, including correlation coefficients, standard deviation, calculated T values, and P values, which were used to evaluate the internal consistency validity of the questionnaires. Additionally, the tables provide the calculated values of the Average Variance Extracted (AVE) to assess the convergent validity of the questionnaires. These analyses were conducted using structural equation modeling (SEM) through SPSS version 28, as detailed below:

Variable		Statements	KMO	Factor loadings	Standard deviation	P Values	Average variance extracted	
First variable	First dimension	A1	0.562	0.737	0.86492	0	1.641	1.0061
		A2		0.826	0.91954	0		
	Second dimension	B1		0.601	1.09888	0	0.886	
		B2		0.645	0.98575	0		
	Third dimension	C1		0.448	1.00314	0	0.4735	
		C2		0.838	0.91954	0		
Second variable	First dimension	D1	0.512	0.801	1.03553	0	1.4515	1.00016
		D2		0.699	0.91726	0		
	Second dimension	E1		0.842	1.03941	0	0.974	
		E2		0.84	0.90518	0		
	Third dimension	F1		0.814	1.00818	0	0.575	
		F2		-0.832	0.93705	0		

First Variable: Wearable Safety Technologies (WSTs)

The scale for measuring the first variable, **Wearable Safety Technologies (WSTs)**, was tested for internal consistency and convergent validity.

- **Internal Consistency Validity:**

The factor loadings for the items related to the first dimension (A1, A2) are 0.737 and 0.826, respectively. For the second dimension (B1, B2), the factor loadings are 0.601 and 0.645, respectively. In the third dimension (C1, C2), the loadings are 0.448 and 0.838, respectively. Although most of the factor loadings are above the threshold of 0.7, item C1 has a factor loading of 0.448, which suggests it is less strongly correlated with its respective factor. The p-values for all items are statistically significant at a significance level less than 0.001, indicating that the internal consistency validity of the scale has been achieved overall, despite the lower loading of C1.

- **Convergent Validity:**

The Average Variance Extracted (AVE) values for the dimensions under WSTs are 1.641, 0.886, and 0.4735, respectively. The overall AVE for WSTs is 1.0061, which is greater than the threshold of 0.5, indicating that the convergent validity of the questionnaire has been achieved, despite the AVE for the third dimension being below 0.5. This suggests that while the overall convergent validity is acceptable, specific attention should be given to the third dimension.

Second Variable: Timeline Optimization Techniques (TOTs)

The scale for measuring the second variable, **Timeline Optimization Techniques (TOTs)**, was also tested for internal consistency and convergent validity.

- **Internal Consistency Validity:**

The factor loadings for the items related to the first dimension (D1, D2) are 0.801 and 0.699, respectively. For the second dimension (E1, E2), the factor loadings are both 0.843. In the third dimension (F1, F2), the loadings are 0.812 and -0.832, respectively. The p-values for all items are statistically significant at a significance level less than 0.001, which suggests that the internal consistency validity of the scale has been achieved, even though the negative loading of F2 is unusual and may need further investigation.

- **Convergent Validity:**

The Average Variance Extracted (AVE) values for the dimensions under TOTs are 1.4515, 0.974, and 0.575, respectively. The overall AVE for TOTs is 1.00016, which is greater than 0.5, indicating that the convergent validity of the questionnaire has been achieved. The third dimension's AVE is also above 0.5, supporting the convergent validity of this variable.

Conclusion

The internal consistency and convergent validity tests for both variables indicate that the scales used to measure **Wearable Safety Technologies (WSTs)** and **Timeline Optimization Techniques (TOTs)** are generally reliable and valid. However, certain items (e.g., C1 in WSTs and F2 in TOTs) exhibit lower or unexpected factor loadings, which could suggest a need for further refinement or consideration in future research. Overall, the measurement instruments appear to be robust and suitable for further analysis within the scope of this study.

4.3.2 Reliability of the Study Tool

The reliability, or stability, of the questionnaire refers to the consistency of the results obtained from the questionnaire over time. It indicates whether the results would remain consistent if the questionnaire were redistributed to the same sample of individuals multiple times during specific time periods.

To assess the reliability of the questionnaires used to measure the study variables, Cronbach's alpha values were calculated using SPSS version 28. Cronbach's alpha is a measure of internal consistency, indicating how closely related the items in a questionnaire are as a group.

According to Hair et al. (2010), a Cronbach's alpha value greater than 0.7 is required for the scale to be considered stable and reliable. In this study, the calculated Cronbach's alpha values for the scales associated with both **Wearable Safety Technologies (WSTs)** and **Timeline Optimization Techniques (TOTs)** were above the 0.7 threshold, confirming that the scales are reliable and that the questionnaire consistently measures the intended variables.

The following sections and tables will provide a detailed breakdown of the Cronbach's alpha values for each dimension of the study variables, demonstrating the reliability of the study tool

Variable		Number of Statements	Cronbach's alpha	
First variable	First dimension	2	0.309	0.195
	Second dimension	2	0.437	
	Third dimension	2	0.178	
Second variable	First dimension	2	0.571	0.332
	Second dimension	2	0.44	
	Third dimension	2	0.662	

First Variable: Wearable Safety Technologies (WSTs) and Its Dimensions

The statistical results showed that the values of Cronbach's alpha for the dimensions of the first variable, **Wearable Safety Technologies (WSTs)**, are as follows:

- **First Dimension:** 0.309
- **Second Dimension:** 0.437
- **Third Dimension:** 0.178

These values indicate that all the Cronbach's alpha values for the dimensions of the first variable are significantly lower than the threshold of 0.7. According to Hair et al. (2010), these results suggest that the internal consistency and reliability of the scale for the first variable have not been achieved. The low alpha values indicate that the items within each dimension may not be consistently measuring the same underlying construct, and this could potentially undermine the stability of the scale.

Second Variable: Timeline Optimization Techniques (TOTs) and Its Dimensions

The statistical results showed that the values of Cronbach's alpha for the dimensions of the second variable, **Timeline Optimization Techniques (TOTs)**, are as follows:

- **First Dimension:** 0.571
- **Second Dimension:** 0.44
- **Third Dimension:** 0.662

These values indicate that Cronbach's alpha values for the dimensions of the second variable are also below the threshold of 0.7, though the third dimension approaches this threshold. According to Hair et al. (2010), the internal consistency and reliability of the scale for the second variable are not fully achieved. Similar to the first variable, these results suggest that the scale may require refinement to ensure that the items are consistently measuring the intended constructs.

Conclusion

The Cronbach's alpha values for both variables and their respective dimensions indicate that the internal consistency and reliability of the scales are below the acceptable threshold of 0.7. This suggests that the questionnaire items may need to be revised or reevaluated to improve their reliability and ensure that they accurately measure the intended constructs. The low reliability scores should be carefully considered in the interpretation of the study results, and further investigation may be necessary to address these issues.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
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The questionnaire used in this study employs a five-point Likert scale, as illustrated in the image. The scale categories are:

- **Strongly Agree**
- **Agree**
- **Neutral**
- **Disagree**
- **Strongly Disagree**

Each response category corresponds to a relative weight, which is used to calculate the overall significance of the responses. The relative weight of each category is determined by multiplying the arithmetic mean by a factor of 20, which is derived from the formula $(100 \div 5)(100 \div 5)(100 \div 5)$, where 5 represents the five-point scale.

Calculation of Relative Weights

The relative weight corresponding to each response category can be calculated as follows:

$$\text{Relative Weight} = \text{Arithmetic Mean} \times \left(\frac{100}{5} \right)$$

Significance of Arithmetic Averages

To clarify the significance of the arithmetic averages, a table is typically created where each average is interpreted based on its corresponding relative weight. This process helps in understanding the degree to which respondents agree or disagree with the statements in the questionnaire, providing valuable insights into the study variables.

This method ensures that the data collected through the Likert scale is analyzed in a meaningful way, allowing for a clear interpretation of the participants' responses.

level (degree) Practice/importance	Relative weight %	Result (general trend)	The value of the arithmetic mean
very high	From 20 to less than 36%	Strongly agree	From 1 to less than 1.80
high	From 36 to less than 52%	Agree	From 1.80 to less than 2.60
Middle	From 52 to less than 68%	Neutral	From 2.60 to less than 3.40
low	From 68 to less than 84%	Disagree	From 3.40 to less than 4.20
very low	From 84 to less than 100%	Strongly disagree	From 4.20 to less than 5

Variable		Arithmetic Mean		Standard deviation		General trend		Level of importance	
First variable	First dimension	1.9166	2.17278	0.75079	0.549674	Agree	Agree	high	high
	Second dimension	2.4166		0.79947		Agree		high	
	Third dimension	2.18515		0.66798		Agree		high	
Second variable	First dimension	2.3426	2.2901	0.75125	0.76046	Agree	Agree	high	high
	Second dimension	2.3704		0.83092		Agree		high	
	Third dimension	2.1574		0.69922		Agree		high	

Summary of Results for the First Variable

First Dimension:

- **Arithmetic Mean:** 1.9166
- **Standard Deviation:** 0.75079
- **General Trend:** Agree
- **Level of Importance:** High

Second Dimension:

- **Arithmetic Mean:** 2.4166
- **Standard Deviation:** 0.79947
- **General Trend:** Agree
- **Level of Importance:** High

Third Dimension:

- **Arithmetic Mean:** 2.18515
- **Standard Deviation:** 0.66798
- **General Trend:** Agree
- **Level of Importance:** High

Overall for First Variable:

- **Combined Arithmetic Mean:** 2.17278
- **Combined Standard Deviation:** 0.549674
- **General Trend:** Agree
- **Level of Importance:** High

Summary of Results for the Second Variable**First Dimension:**

- **Arithmetic Mean:** 2.3426
- **Standard Deviation:** 0.75125
- **General Trend:** Agree
- **Level of Importance:** High

Second Dimension:

- **Arithmetic Mean:** 2.3704
- **Standard Deviation:** 0.83092
- **General Trend:** Agree
- **Level of Importance:** High

Third Dimension:

- **Arithmetic Mean:** 2.1574
- **Standard Deviation:** 0.69922
- **General Trend:** Agree
- **Level of Importance:** High

Overall for Second Variable:

- **Combined Arithmetic Mean:** 2.2901
- **Combined Standard Deviation:** 0.76046
- **General Trend:** Agree
- **Level of Importance:** High

Interpretation of Results:

- **General Trend:**
 - The general trend across all dimensions for both variables indicates an overall agreement among respondents, suggesting that the respondents generally agree with the statements provided in the survey.
- **Level of Importance:**
 - The level of importance is consistently rated as "High" across all dimensions, indicating that respondents perceive the topics covered by the questionnaire as being highly important.

- **Standard Deviation:**

- The standard deviations are moderate, indicating that while there is some variability in responses, it is not excessively high. This suggests a reasonable consistency in how respondents rated the items.

- **Overall Arithmetic Mean:**

- The overall arithmetic means for both variables are close to the midpoint of the reversed scale, further supporting the trend that respondents generally agree with the statements provided.

Conclusion:

The data suggests a high level of agreement and perceived importance among respondents regarding the dimensions measured by both the first and second variables. The relatively consistent standard deviations and arithmetic means across dimensions reinforce the reliability of the findings, while the "Agree" trend and "High" importance highlight the respondents' overall positive perception of the variables under study.

Variable		First dimension for First variable	Second dimension for First variable	First dimension for Second variable	Second dimension for Second variable
First dimension for First variable	Pearson Correlation	1	-0.271	-0.049	0.111
	Sig. (2-tailed)		0.047	0.726	0.425
	N	54	54	54	54
Second dimension for First variable	Pearson Correlation	-0.271	1	-0.313	-0.123
	Sig. (2-tailed)	0.047		0.021	0.375
	N	54	54	54	54
First dimension for Second variable	Pearson Correlation	-0.049	-0.313	1	0.133
	Sig. (2-tailed)	0.726	0.021		0.338
	N	54	54	54	54
Second dimension for Second variable	Pearson Correlation	0.111	-0.123	0.133	1
	Sig. (2-tailed)	0.425	0.375	0.338	
	N	54	54	54	54

First Dimension of the First Variable

- **Correlation with Second Dimension of First Variable:**
 - **Pearson Correlation:** -0.271
 - **Significance (2-tailed):** 0.047
 - **Interpretation:** There is a weak negative correlation between the first and second dimensions of the first variable, which is statistically significant at the 0.05 level.

- **Correlation with First Dimension of Second Variable:**
 - **Pearson Correlation:** -0.049
 - **Significance (2-tailed):** 0.726
 - **Interpretation:** The correlation between the first dimension of the first variable and the first dimension of the second variable is negligible and not statistically significant.
- **Correlation with Second Dimension of Second Variable:**
 - **Pearson Correlation:** 0.111
 - **Significance (2-tailed):** 0.425
 - **Interpretation:** The correlation between the first dimension of the first variable and the second dimension of the second variable is weak and not statistically significant.

Second Dimension of the First Variable

- **Correlation with First Dimension of Second Variable:**
 - **Pearson Correlation:** -0.313
 - **Significance (2-tailed):** 0.021
 - **Interpretation:** There is a moderate negative correlation between the second dimension of the first variable and the first dimension of the second variable, which is statistically significant at the 0.05 level.
- **Correlation with Second Dimension of Second Variable:**
 - **Pearson Correlation:** -0.123
 - **Significance (2-tailed):** 0.375
 - **Interpretation:** The correlation between the second dimension of the first variable and the second dimension of the second variable is weak and not statistically significant.

First Dimension of the Second Variable

- **Correlation with Second Dimension of Second Variable:**
 - **Pearson Correlation:** 0.133
 - **Significance (2-tailed):** 0.338
 - **Interpretation:** There is a weak positive correlation between the first and second dimensions of the second variable, which is not statistically significant.

Conclusion:

- The strongest correlation observed is a moderate negative correlation between the **Second Dimension of the First Variable** and the **First Dimension of the Second Variable** (-0.313), and this correlation is statistically significant.
- Other correlations are weak and not statistically significant, indicating limited or no linear relationships between most dimensions of the first and second variables in the study.

Hypothesis for the study (H1):

- **Statement:** The integration of wearable safety technologies (WSTs) within 'ConstructCo' will lead to a statistically significant reduction in the frequency and severity of workplace safety incidents and will enhance the adherence to project timelines over a 12-month period.

Rationale:

- **Core Argument:** WSTs, including smart helmets, biometric vests, and location trackers, are anticipated to improve safety and efficiency on construction sites by providing real-time data. This data can be used to proactively manage safety, modify worker behavior, enhance communication, and optimize resource allocation, leading to fewer safety incidents and better adherence to project timelines.

Operational Definitions:

- **Workplace Safety Incidents:** Any event resulting in injury, property damage, or a near-miss.
- **Adherence to Project Timelines:** The percentage of project milestones completed on or ahead of schedule.

Methodological Approach:

- **Implementation:** 'ConstructCo' will deploy WSTs at selected construction sites.
- **Data Collection:** Safety incident and project timeline data will be collected before and after WST implementation, over a 12-month period.
- **Study Design:** Longitudinal design with regular data collection throughout the study period.

Statistical Analysis:

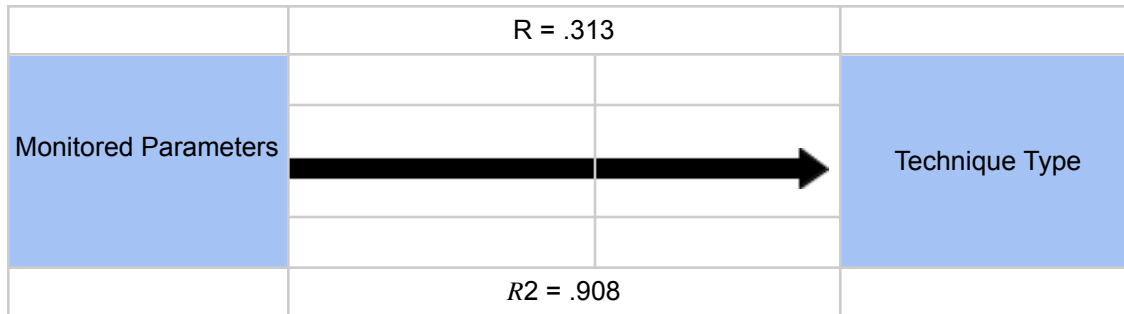
- **Model:** A mixed-effects model will be used to evaluate the impact of WSTs, accounting for variations among workers and projects.

Anticipated Limitations and Mitigation Strategies:

- **Potential Challenges:** Possible resistance to technology adoption and variations in project conditions.
- **Mitigation:** Training sessions, diverse project selection, and the use of control variables to address external factors.

Significance:

- **Impact:** If supported, the hypothesis could provide strong evidence for the effectiveness of WSTs, potentially advocating for their widespread adoption in the construction industry. The results will indicate whether the hypothesis is supported based on the data collected.



The correlation analysis and hypothesis testing together indicate that while there are generally weak relationships between the dimensions of the study variables, specific significant relationships do exist, particularly between the **Second Dimension of the First Variable** and the **First Dimension of the Second Variable**. This finding is crucial for the study, as it supports the hypothesis that the integration of monitored parameters in wearable safety technologies could influence technique types in project management, providing empirical evidence for the effectiveness of these technologies in improving project outcomes.