# A Model Study on the Maintenance Operational Ergonomics of a Typical Posture

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**Keywords:** maintenance ergonomics; Power limit; duration;

**Abstract:** The narrowness of the maintenance work space often leads to the situation that the maintenance personnel are difficult to apply force. The time characteristic of the maintenance force indicates whether the limit strength of the maintenance personnel in the bad posture can overcome the maintenance resistance and determine whether it can complete the given operation. Therefore, based on the analysis results of the key influencing factors of maintenance work efficiency, this paper proposes the design method of upper limb operating force limit measurement experiment, obtains the power limit and force maximum duration data under typical posture, and establishes the maximum force regression model of equipment maintenance operation, which is virtual. Maintainability analysis provides basic strength data. At the same time provide advice to the grassroots maintenance operators.

## 1. Ergonomics overview

Ergonomics mainly studies and explores the interaction between human and various system elements [1], specifically explaining the interaction between human and various hardware, software and even the working environment, and laying a solid theory for its rational combination. And the basis of practice. This kind of technology mainly focuses on human-machine system, which mainly makes the physical and psychological characteristics of various equipments and people fully matched, reduces the difficulty of operation, improves the operating environment, and improves the efficiency of human-machine work[2].

Based on ergonomics and human factors engineering, the maintenance design focuses on human body characteristics and capabilities, which are embodied in three aspects [3]: First,the maintenance design should fully consider the location of the maintenance personnel,the posture maintained and the tools used. In other cases, provide reasonable and effective operation space to avoid prone or fatigued postures such as smashing, smashing, smashing, etc. Secondly, the maintenance design should consider the physical limit of the action of lifting, pushing, turning, etc. of the maintenance personnel during the operation; Third, the maintenance design should be based on the principle of reducing the load on the maintenance personnel and the difficulty of operation, thus ensuring the efficiency and quality of maintenance. Computer-Aided Ergonomics (CAE) came into being. Ergonomics research can be carried out through computer-aided ergonomics software for specific research and application. The software mainly includes: method research and verification software such as STARS, FMS. GSA, etc.; human-machine system engineering application software, such as SAMMIE, Jack, ERGO, etc.[4]. To a certain extent, this solves the problems of traditional maintenance design lag, non-image and over-reliance on physical prototypes. Through the ergonomics theory and the application of related software, the maintenance design can be fully understood at the beginning of weaponry development. The design problems were found to facilitate maintenance and handling after the equipment was finalized[5].

## 2. Main points of concern for maintenance work

Work efficiency or humanity is an important concern of maintainability, but there is no systematic discussion about maintenance work efficiency research methods, but also as an activity of maintenance engineering, which is the status and maintenance of work efficiency in maintenance and repairability. The complexity of the ergonomics itself is not commensurate [6].

From the perspective of ergonomic factors, the basic characteristics of equipment-level maintenance and the research factors of ergonomics can be combined. Maintenance posture is an inevitable factor in equipment maintenance, mainly depending on the working space and equipment layout, and the posture is comfortable. Degree and accumulation of fatigue, but also the use of influence[7]

Action and strength are the key factors that must be considered in maintenance work efficiency, The duration mainly refers to the maintenance personnel's posture duration and duration of exertion, which is an important parameter for the formation of fatigue accumulation. [8]

## 3. Typical posture maintenance ergonomic operation test

### 3.1 Test purposes

According to the actual investigation of the level of maintenance at the base level, the maintenance operation in the posture is simulated in the laboratory. The Maximal Voluntary Contraction (MVC) that the service personnel can apply is measured in the subject position. Based on the relationship between maximum force and duration, a maximum force and duration regression model with high reliability is established.

### 3.2 Tester& Test equipment

In this experiment, 30 people were selected. In order to make the subjects representative, the study selected two parameters according to height and weight. The main reference is GJB/Z 131-2002 "Ergonomics Design Manual for Military Equipment and Facilities" [9]. This study is based on the ratio of the height and weight of 20-25 years old in the Second National Physical Fitness Monitoring Report [10]. Experimental strength test equipment using BTE Primus RS motion measurement evaluation system

Figure 1 BTE Primus RS motion measurement evaluation system

## 4. Test data and analysis

A total of 180 sets of data were collected in this trial. There were 4 groups: maximum right hand screwing force, left hand maximum screwing force, right hand maximum screwing force duration, and left hand maximum screwing force duration.

### 4.1 Maximum force line chart

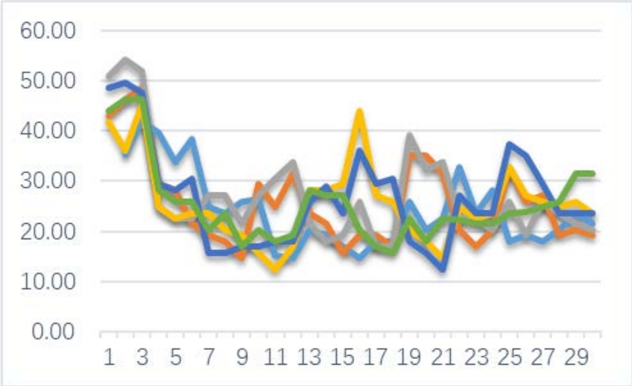


Figure 2 Right hand maximum screwing force line diagram

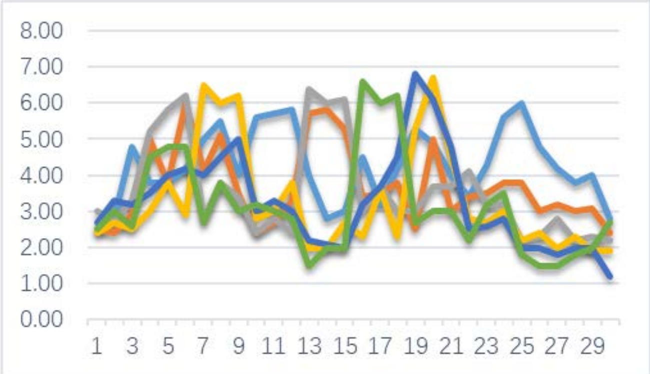


Figure 3 right hand maximum force duration line chart

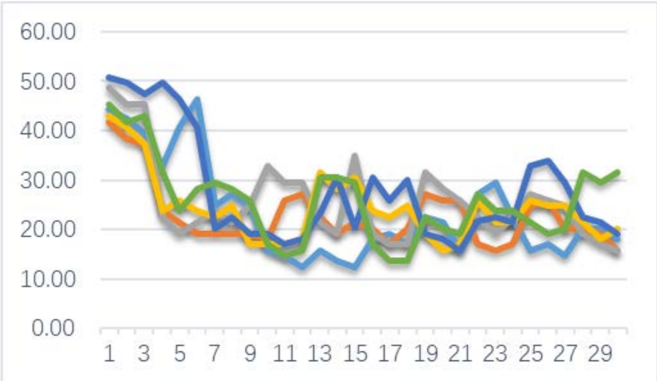


Figure 4 left hand maximum screwing force line diagram

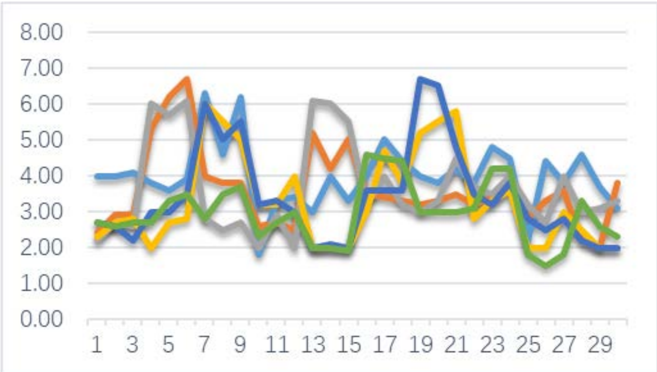


Figure 5 left hand maximum force duration line chart

**4.2 Correlation and regression analysis**

Correlation analysis of left hand maximum screwing force and left hand duration:

TABLE I. Statistical Analysis

| Descriptive statistics | | | |
|---|---|---|---|
| | Average number | standard deviation N | N |
| Left hand maximum force | 25.0337 | 8.73241 | 180 |
| Maximum force duration | 3.4917 | 1.17905 | 180 |

TABLE II. Correlation Analysis

| | | Left hand maximum force | Maximum force duration |
|---|---|---|---|
| Left hand maximum force | Pearson related | 1 | -0.264** |
| | Significant(twotailed) | | 0.000 |
| | N | 180 | 180 |
| Maximum force duration | Pearson related | -0.264* | 1 |
| | Significant(twotailed) | 0.000 | |
| | N | 180 | 180 |

**. Correlation is significant on the 0.01 layer (two-tailed)

Regression analysis result:

TABLE III. Model Summary

| Model | R | R squared | Adjusted R square | Standard skewness error |
|---|---|---|---|---|
| 1 | 0.264[a] | 0.070 | 0.065 | 1.14035 |

In Table 4, in the model summary, the correlation coefficient is R=0.264, the goodness of fit is R square=0.070, the adjusted goodness of fit is 0.065, and the error of the standard deviation estimation is 1.14035.

TABLE IV. Analysis of Variance

| Model | | Square sum | df | Mean squared | F | Significant |
|---|---|---|---|---|---|---|
| 1 | Return | 17.365 | 1 | 17.366 | 13.354 | 0.000[b] |
| | Residual | 231.471 | 178 | 1.300 | | |
| | total | 248.838 | 179 | | | |

TABLE V. Coefficient

| Model | | Non-standardized coefficient | | standardized coefficient | T | Significant |
|---|---|---|---|---|---|---|
| | | B | Standard error | Beta | | |
| 1 | (constant) | 4.776 | 0.292 | | 16.332 | 0.000 |
| | Left hand maximum force | -0.048 | 0.011 | -0.318 | -4.459 | 0.000 |

From this table, we can get the one-way regression model of the left hand maximum screwing force and left hand duration:

$$Y = -0.036X + 4.385$$

### 4.3 Correlation analysis of the right hand's maximum screwing force and right hand duration

TABLE VI. Descriptive statistics

| Descriptive statistics | | | |
|---|---|---|---|
| | Average number | standard deviation N | N |
| Right hand maximum force | 25.8907 | 8.72138 | 179 |
| Maximum force duration | 3.5402 | 1.31031 | 179 |

TABLE VII. Correlation analysis

| | | right hand maximum force | Maximum force duration |
|---|---|---|---|
| right hand maximum force | Pearson related | 1 | -0.318** |
| | Significant(twotailed) | | 0.000 |
| | N | 179 | 179 |
| Maximum force duration | Pearson related | -0.318** | 1 |
| | Significant(twotailed) | 0.000 | |
| | N | 179 | 179 |

**. Correlation is significant on the 0.01 layer (two-tailed)

Regression analysis result:

TABLE VIII. Model Summary

| Model | R | R squared | Adjusted R square | Standard skewness error |
|---|---|---|---|---|
| 1 | 0.318a | 0.101 | 0.096 | 1.24590 |

TABLE IX. Analysis of variance

| Model | | Square sum | df | Mean squared | F | Significant |
|---|---|---|---|---|---|---|
| 1 | Return | 30.860 | 1 | 30.860 | 19.881 | 0.000[b] |
| | Residual | 274.750 | 177 | 1.552 | | |
| | total | 305.610 | 178 | | | |

TABLE X. Coefficient

| Model | | Non-standardized coefficient | | standardized coefficient | T | Significant |
|---|---|---|---|---|---|---|
| | | B | Standard error | Beta | | |
| 1 | (constant) | 4.776 | 0.292 | | 16.332 | 0.000 |
| | Left hand maximum force | -0.048 | 0.011 | -0.318 | -4.459 | 0.000 |

From this table, we can get the one-way regression model of the left hand maximum screwing force and left hand duration:

$$Y = -0.048X + 4.776$$

### 4.4 Conclusion

Through the main focus of maintenance work efficiency, this test selects the operating force and the maximum force duration as the key factors. In the typical posture of sitting posture, the operating force limit and the maximum force duration are measured, and the maximum right-hand screwing force is obtained through the test. , the maximum force of the left hand, the maximum force of the right hand and the duration of the left hand. Analyze and compare the maximum force data and the maximum force duration data, it can be concluded that the maximum hand screwing force of the right hand is larger than that of the left hand. The screwing force line graph indicates that the left hand fluctuation is larger than the right hand, that is, the right hand is relatively stable during the maintenance operation, so it is large. The maintenance personnel will use the right hand in some maintenance operations. The duration of the screwing force and the force is a negative correlation, and as the screwing force increases, the duration decreases rapidly.

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