An Indirect Approach to Analyze the Impact of Working Environment Restrictions Due To COVID 19 on Muscle Fatigue and Strength

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Abstract

The current research work seeks to analyze the changes in the muscle fatigue and strength, if any, due to the restrictions of use of facial mask while at work. The workers are required to perform tasks like lifting and pushing which range from moderate to heavy workloads. Alternative approach had to be used as the shop floor environment did not facilitate the use of standard laboratory setup for measurement of muscle fatigue.

Keywords
Muscle fatigue, ergonomics, workloads, discomfort, COVID

1. Introduction
Unprecedented changes have taken place in the work environment due to COVID 19. These being an unchartered path, new set of working norms were introduced to ensure the safety of employees at the work place. This had to be done to ensure the economic survival of the industry as a whole. This situation has given rise to many new requirements, like re-setting of production norms and other related allowances like fatigue and policy allowance. It is still very new for any norms to be finalised, so an attempt to evaluate the impact of working restrictions like wearing of facial mask imposed due to COVID 19, on the workers, working on the shop floor. This is going to affect the productivity of the industry, already under tremendous financial strain to accommodate the restrictions for every ones health and safety.

1.1Objectives
The objective of this study was to determine the changes in fatigue experienced due to use of facial mask for protection against COVID 19, which may lead to productivity loss on the shop floor.

2. Literature Review
The Maharashtra Government along with the Central Government, have issued the following guidelines which are a very tight rope walk for Medium and Small Scale Industries around Pune.

Guidelines for the workers
1. Ensure 24 -hour sanitisation of the factory premises.
   - Factories need to maintain a sanitisation routine every two-three hours especially in the common areas that include lunch rooms and common tables which will have to be wiped clean with disinfectants after every single use.

- For accommodation, sanitisation needs to be performed regularly to ensure worker safety and reduce the spread of contamination.

2. Entrance health checks
   - Temperature checks of all employees to be done twice a day.
   - Workers showing symptoms should not report to work.

3. Provisions of hand sanitisers and mask to all employers.
   - Providing gloves, masks and hand sanitisers to be done at all factories and manufacturing units.

4. COVID 19 health and prevention staff education
   - Education on safety steps to take from entry to exit in the factory
   - Measures to take precautions at personal level

5. Quarantine measures for supply and storage of goods
   - Sterilise boxes and wrapping brought into factory premises
   - Isolate and sanitise finished goods as appropriate
   - Delivery of goods in shifts

6. Physical distancing measures
   - Create physical barriers to ensure the physical distance within the work floor and dining facilities
   - Provide face protection shields along with masks and PPEs.

7. Working in shifts
   - Factories that work 24 hours at full production capacity should consider one hour gap between shifts, except factories/plants requiring continuous operations.
   - Managerial and administrative staff should work one shift at 33 per cent capacity as per MHA guidelines; but while deciding which particular person to be included in 33% at any given point of time, overriding priority should be given to personnel dealing with safety.
   - Ensure no sharing of tools or workstations to the extent possible. Provide additional sets of tools if needed.

8. Scenario plan on discovering a positive case
   - Factories have to prepare accommodation to isolate workers, if needed.
   - HR has to help manage the whole process for individual, all travelling employees also to undergo a mandatory14-day quarantine

9. Presence of skilled workers
   - Workers involved in dealing with hazardous material must be skilled and experienced in the field. No compromise on deployment of such workers should be permitted when an industrial unit is opened up.

On this background, the research was conducted to find if there is an increase in fatigue of manual labour.Numerous methods have been used in measurement of fatigue. Despite the discomfort, people can maintain their muscle contraction for a period longer than the endurance time, if motivated to do so[7]. Thus the strength and endurance curve is obscured making it difficult to measure even force fatigue quantitatively[7]. A direct technique of muscle fatigue measurement is EMG (Electromyography). Electromyography has been considered a reliable tool for an indication of localized muscle fatigue[4,5]

It has been understood that there is no single and direct reliable quantitative measure of localized and overall muscle fatigue. Therefore, we can find different authors have chosen one of the varieties of indicators of fatigue, such as EMG median frequency, muscle deoxygenation, oxygen uptake, heart rate, rate of perceived exertion (RPE) and visual analog scale (VAS) scores[7]. But, measuring fatigue by direct methods like EMG have practical limitations on the shop floor.

3. **Methods**

3.1 Paired Sample T-Test

The paired sample *t*-test, sometimes called the dependent sample *t*-test, is a statistical procedure used to determine whether the mean difference between two sets of observations is zero. In a paired sample *t*-test, each subject or entity is measured twice, resulting in *pairs* of observations. Common applications of the paired sample *t*-test include case-control studies or repeated-measures designs. In this case the interest is in evaluating the impact of using mask while doing manual labour. The approach considered was to measure the performance of a sample of employees till a need for rest was felt, without facial mask and with facial mask, and analyze the differences using a paired sample *t*-test.

3.2 Hypotheses

Like many statistical procedures, the paired sample *t*-test has two competing hypotheses, the null hypothesis and the alternative hypothesis. The null hypothesis assumes that the true mean difference between the paired samples is zero. Under this model, all observable differences are explained by random variation. Conversely, the alternative hypothesis assumes that the true mean difference between the paired samples is not equal to zero. The alternative hypothesis can take one of several forms depending on the expected outcome. If the direction of the difference does not matter, a two-tailed hypothesis is used. Otherwise, an upper-tailed or lower-tailed hypothesis can be used to increase the power of the test. The null hypothesis remains the same for each type of alternative hypothesis. The paired sample *t*-test hypotheses are formally defined below:

- The null hypothesis (H_0) assumes that the true mean difference (μ_d) is equal to zero.
  - The two-tailed alternative hypothesis (H_1) assumes that μ_d is not equal to zero.
  - The upper-tailed alternative hypothesis (H_1) assumes that μ_d is greater than zero.
  - The lower-tailed alternative hypothesis (H_1) assumes that μ_d is less than zero.

The mathematical representations of the null and alternative hypotheses are defined below:

- H_0: $\mu_d = 0$
- H_1: $\mu_d \neq 0$ (two-tailed)
- H_1: $\mu_d > 0$ (upper-tailed)
- H_1: $\mu_d < 0$ (lower-tailed)

It is important to remember that hypotheses are never about data, they are about the processes which produce the data. In the formulas above, the value of μ_d is unknown. The goal of hypothesis testing is to determine the hypothesis (null or alternative) with which the data are more consistent.

3.3Assumptions

As a parametric procedure (a procedure which estimates unknown parameters), the paired sample *t*-test makes several assumptions. Although *t*-tests are quite robust, it is good practice to evaluate the degree of deviation from these assumptions in order to assess the quality of the results. In a paired sample *t*-test, the observations are defined as the differences between two sets of values, and each assumption refers to these differences, not the original data values. The paired sample *t*-test has four main assumptions:

- • The dependent variable must be continuous (interval/ratio).
- • The observations are independent of one another.
- • The dependent variable should be approximately normally distributed.
- • The dependent variable should not contain any outliers.

4. Data Collection / Application of research methods

The data was collected at an Indian industrial establishment on metal shearing and bending machines. (Table 1: Raw Data). Some representative photographs show the limited space and manpower used in such an industry. (Refer Figure1, Figure 2, Figure 3, Figure 4 and Figure 5)

Pre - COVID 19:

Figure 1. Normal Working Conditions pre-COVID19

Post COVID 19:

Figure 2. Normal Working Conditions pre-COVID19

Figure 3. Normal Working Conditions post-COVID19

Figure 4. Normal Working Conditions p0st-COVID19

Figure 5. Normal Working Conditions post-COVID19

4.1 Observation of oxygen levels (SPO_2 %) was attempted by use of portable oximeter, but the oil contamination and sweat on the fingers did not provide correct readings.

4.2 An indirect method was used to determine the change in fatigue level. This was done by measuring the time worked (minutes) before break (10 minutes).The initial practice followed by Management was granting the policy allowance (to overcome fatigue) of 10 minutes per 60 minutes work, for sheet thickness up to 6mm. For sheet thickness above 6 mm, policy allowance of 10 minutes per 45 minutes work was granted.Post COVID 19, it was observed that there was a deviation in the break pattern when working while wearing mask. More frequent breaks were taken by workers and this was required for fatigue recovery The need to study the impact on productivity was felt as the workers were sufficiently motivated to work being paid on piece rate system.

Statistical analysis was performed by using ANOVA (Population normal, population finite, sample size small and variance of the population unknown, and H_a may be one-sided or two-sided) to validate the same. Paired t-test is a way to test for comparing two related samples, involving small values of n that does not require the variances of the two populations to be equal, but the assumption that the two populations are normal must continue to apply. For a paired t-test, it is necessary that the observations in the two samples be collected in the form of what is called matched pairs i.e., "each observation in the one sample must be paired with an observation in the other sample in such a manner that these observations are somehow "matched" or related, in an attempt to eliminate extraneous factors which are not of interest in test." Such a test is generally considered appropriate in a before-and-after-treatment study[9].

The null hypothesis for testing of difference between means is generally stated as H_0: $\mu_1 = \mu_2$, where μ_1 is population mean of one population and μ_2 is population mean of the second population, assuming both the populations to be normal populations. Alternative hypothesis may be of not equal to or less than or greater than type[9].

It is assumed to have a normally distributed population with the following parameters - Population normal, population finite, sample size small and variance of the population unknown, and H_a (alternative hypothesis) may be one-sided or two-sided, and Significance Level (Alpha) = 0.05

Table 1: Raw Data

Temperature (deg C) >							25	31	33	28	30	
Humidity % >							88	64	64	73	69	
Material	Thickness (mm)	Length X Breadth (mm)	Weight of Sheet (kg)	No. of persons	Weight Lifted per Person	**std. working time before break (minutes)**			**post COVID 19 working time before break (minutes)**			**Average Working Time (minutes)**
						w/o Mask			**with Mask**			**with Mask**
									DAY			
							1	**2**	**3**	**4**	**5**	
En8	2	1250 X 2500	49.06	2	24.53	**60**	60	59	56	60	58	**58.6**
En8	4	1250 X 2500	98.13	4	24.53	**60**	42	49	45	44	51	**46.2**
En8	6	1250 X 2500	147.19	4	36.80	**60**	45	49	51	48	50	**48.6**
En8	8	1250 X 2500	196.25	4	49.06	**45**	39	45	44	41	42	**42.2**
En8	10	1250 X 2500	245.31	4	61.33	**45**	30	31	29	26	33	**29.8**

5. Results and Discussion

It can be observed from the result table that:

Table 2: Statistical Analysis

t-Test: Paired Two Sample for Means		
	Time before Break was required ***W/O Mask***	***Time before Break was required*** ***With Mask***
Mean	54 minutes	45.08 minutes
Variance	67.5	109.552

Observations	5	5
Pearson Correlation	0.791926854	
Hypothesized Mean Difference	0	
df	4	
Significance Level (Alpha)	0.05	
t Stat	3.12063658	
P(T<=t) one-tail	0.017752389	
t Critical one-tail	2.131846782	
P(T<=t) two-tail	0.035504778	
t Critical two-tail	2.776445105	

[1] The Pearson Correlation coefficient of 0.79 indicates a high level of correlation between the means.(Table 2)

[2] As the t Stat (3.1206) is higher than the t Critical two tail (2.776), we REJECT the null hypothesis that both the means are equal. (Table 2)

6. Conclusion

It can be concluded that there is increased fatigue experienced by the workers involved in moderate to heavy intensity of physical activity, due to use of facial mask for protection against COVID 19, which may lead to productivity loss on the shop floor by about 8% to 12%. This value of loss will change depending upon the policy allowances provided by the Management based on the ambient conditions. Research is being conducted to determine the best suited mask for such working conditions. Further research needs to be undertaken to find if feeling of discomfort is felt by the workers due to which there is a decrease in productivity.

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