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THE INFLUENCE OF "BIORHYTHM" ON THE INCIDENCE OF INJURIES AMONG AGRA FOUNDRY WORKERS

RANJIT SINGH[1], ROHIT SHARMA[2]
[1]Faculty of Engineering, Dayalbagh Educational Institute, Dayalbagh, Agra, 282005, India
[2]Faculty of Engineering, Dayalbagh Educational Institute, Dayalbagh, Agra, 282005, India
Corresponding Author: Email- r25sharma@gmail.com

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Abstract- The purpose of this study was to investigate the effects of three basic cyclic rhythms called biorhythms including a 23-day physical cycle, a 28-day emotional cycle and a 33-day intellectual cycle on the incidence of accidents in Agra casting manufacturing units. For this purpose a sample of 462 accidents were randomly selected for the analysis. The statistical methods chi-square of significance level p<0.05and 95%CI were used to determine the significance of the study. Results of the study showed that Chi-square values were significant at p<0.05 in all the cases except in the case of serious accidents as response of results were mixed but the value of 95%CI is significant in all the cases as the values were much more than expected to occur on critical days purely by chance 20.4%. It was found, using alternative definition 4 of the critical days that 67.2% of accidents in case of total number of accidents examined and 72.8% of accidents in case of serious accidents were occurring on critical days for the various combinations of alternative critical days definition, which were higher than the other alternative definitions of critical days. Present work suggested that biorhythm theory acts as an information system and may be implemented in the industries in which chances of workers to get stuck with accidents are more.
Relevance to industry- Some industrial activities involve lifting and carrying heavy loads or working in dusty, fummy, and heated environment. Such tasks may lead to various types of accidents to the workers. This study investigated the effects of biorhythm on industrial accidents, so that the workers could be kept away from the hazardous tasks on critical days. The results may provide useful information for further study in the prevention of industrial accidents.
Keywords: Biorhythm, Physical, Emotional, Intellectual, critical days, accidents, foundry, Biological cycle

Introduction

One out of every ten workers afflicted with a job related illness or injury. It is evident why safety is one of industry's highest priorities. If emphasis can be placed on safety during low periods of human performance, this awareness itself may contribute to accident prevention. The science of "Biorhythm" is the science of predicting human performance by means of understanding biological rhythms. Biorhythm theory suggests that people's behavior is affected by three biological cycles that start at birth and continue through life. Biorhythm cycles are believed to originate from the day of birth and from a base line begin their cyclical variation with an initial upward swing. These cycles have been termed: (1) physical cycle is the biological cycle which lasts 23 days originates in the muscle cells and fibers and helps to govern the degree of strength, vitality, endurance, resistance, and physical confidence of the individual; (2) emotional cycle is the biological cycle which lasts 28 days governs the nervous system and influences creative enterprise, feelings, love, cooperation, and all coordination dealing with the nervous system; (3) intellectual cycle is the biological cycle which lasts 33 days governs the brain and regulates intelligence, logic, mental reaction, alertness, sense of direction, decision-making, judgment, power of deduction, memory, and ambition[17]. These cycles have traditionally been depicted as sine curves, as shown in Figure 1. According to the theory each cycle has three distinct phases. The first, or positive, phase i.e, above the birth base line is said to be associated with strong, creative, stimulating activity while the second, or negative, phase i.e, below the base line is said to be associated with weak, irritable, indecisive activity. The third is the critical or transition phase that cross the base line means the period during which the biorhythm changes from positive to negative or vice versa. This phase is said to be an unstable or turbulent period during which "a person's predisposition to react to vital situations is not at an optimal level" [3]. There are two critical days for each cycle [16]. Taking each cycle in turn it is, then, possible to predict the state of the individual. However, as the cycles are not of the same length they very rarely coincide with one another. Hence, on any particular day you have a mixture of rhythms that have to be interpreted accordingly.

Popular claims have been made that traffic and industrial accidents are more likely to occur during a person’s critical days and that the biorhythmic model can be used to prevent these incidents, In Switzerland, where airline pilots were not allowed to fly on the days when they had a physical crossover the minor accident rates due to pilot error fell by some 70% and in the same country Dr. Wehrli testified that he performed over 10,000 operations without a single failure or complication for fifteen years by selecting the best days for operations. The Nagahama Transport division of the Omi Railway did this and established a totally accident free record over 4 million kilometers. The Meiji Bread Company cut their annual vehicle accident rate by 45% and saved 3.5 million yen the year they began using the Biorhythm theory [6]. A number of authors have found evidence to support these studies [1, 10, 14, 19, 20] and others have reported a lack of correlation of accidents and the designated critical days [2, 9, 11, 13, 15, 16, 21, 22]. A comparison between these studies is impossible because many of them have not been specific about the methodology used and deficiency in the literature and statistics used [4, 5]. The current study was attempted to resolve some of these contradictions and analysis the effects of biorhythm on the incidence of injuries in Agra casting manufacturing units.

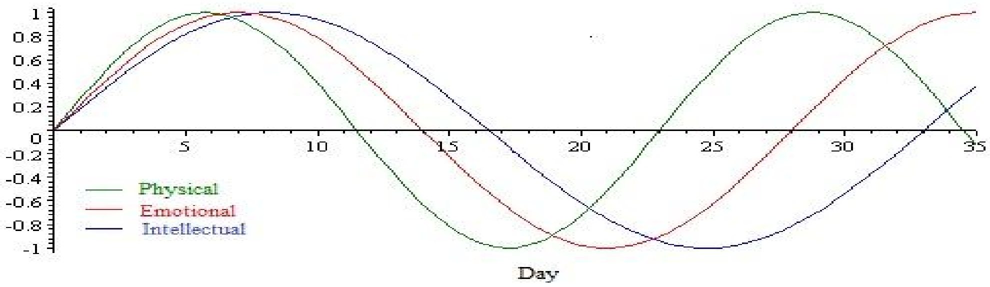

Fig. 1. Biorhythm Cycles

Methods

Details of 530 accidents and Individual employee details, such as birth dates, were taken directly from personnel records at the industry’s head office. Accidents and personnel records were matched, and 68 accidents were rejected because of missing information or because no birth date was recorded, As a result of these exclusions, a total of 462 accidents were selected for the biorhythm analysis. The accidents included all the injuries related to musculoskeletal disorders and amputations necessitating prolonged medical treatment or hospitalization. The accidents were of a type normally associated with heavy manual work, high speed machines, and mobile equipment. Injuries resulting from long term exposure, such as hearing losses were excluded. The physical, emotional and intellectual biocurves were produced for each worker by means of a biorhythm calculator and the actual frequencies of the accidents were obtained. Data is calculated in three ways:

1. The frequencies of accidents were determined for the positive, negative, and critical phases of each cycle.

2. The frequencies of accidents were determined for Critical day definition method. In this method, first three definitions are the same as suggested by Khalil and Kurucz [8] and a fourth alternative definition was added in which last day and two mid days of negative phase of each cycle was added to the original definition of critical days because at the mid of each negative phase of the cycle a person have efficiency at lowest, so these two days of the cycles were also considered as the critical days of the cycle. Four definitions and their related critical days for each cycle are shown in Table 1.

3. A separate data for serious accidents was collected to determine if there was a relationship between critical days and more serious accidents, because some people argue that biorhythm theory predicts only those days on which an individual is at greatest risk. These accidents included:

a) All accidents involving all kinds of MSDs.
b) All accidents involving productivity loss.
c) All accidents in which the injured person was shifted to light work as a result of the injury.

Table 1 Alternative critical day definition

Biorhythm Cycle	Critical Days in Cycle			
	Definition 1	Definition 2	Definition 3	Definition 4
Physical	1,12,13	1,2,12,13,23	1,2,11,12,13,14,23	1,12,13,17,18,23
Intellectual	1,17,18	1,2,17,18,33	1,2,16,17,18,19,33	1,17,18,25,26,33
Emotional	1,15	1,2,15,28	1,2,14,15,16,28	1,15,21,22,28

Statistical Analysis

A test of the relationship between critical days and industrial accidents requires the calculation of expected frequencies of accidents on these days if accidents were occurring randomly. The number of accidents expected to occur by chance on the critical days of each cycle were assumed to be 2/23 x N for the physical cycle, 2/28 x N for the emotional cycle and 2/33 x N for the intellectual cycle. Using the method suggested by Khalil and kurucz [8] the expected frequencies of accidents for various combinations of alternative critical day definitions and of critical days were obtained by calculating probabilities of these various combinations. A Chi-square analysis of significance $P<0.05$ was used to compare the observed frequencies with those expected frequencies of the accidents. In this case chi square statistic can be shown as:

$$\chi^2 = \sum_{j=1}^{n} [(f_{oj} - f_{ej})^2 / f_{ej}] \qquad \text{…………. (1)}$$

Where

f_{oj} = observed accidents for biorhythm day type j

f_{ej} = expected accidents for biorhythm day type j

n = number of biorhythm days

In working with biorhythm data, another method of analysis for establishing whether a significant relationship can be shown between accident occurrence and biorhythm critical days based on a sample is to determine the Confidence Interval (CI) for the true mean proportion of accidents occurring on critical days ("hits") to the total number of accidents. The range or confidence interval is defined by:

$$A + a(\sqrt{A(1-A)/N}) = \mu = A - a(\sqrt{A(1-A)/N}) \qquad \text{………… (2)}$$

Where

A = ratio of "hits" to total number of accidents

N = sample size

$a = 1.96 / \sqrt{N}$

μ = true mean proportion of hits to total accidents

To examine the relationship between the actual and expected frequencies of various combinations of critical days in greater detail 95%CI was applied.

Results and Discussion

Initially all accidents were examined and results were calculated. Table 2 gives a comparison of actual and expected values representing the incidence of injuries in the positive and negative phases of each cycle and critical days of each cycle. The frequency of injuries to be expected from the hypothesis is set out against the actual frequency at each stage of the cycle. The incidence of injuries is distributed relatively evenly between positive and negative cycle phases. And it was found that most of the accidents were occurred on Critical days and negative phase of the cycle. The results obtained on the basis of random expectation differed from the frequencies observed. Chi-square values for physical cycle was 18.3; for emotional cycle was 16.6; and for an intellectual cycle was 20.6 and the values were significant at $p<0.05$ for all biocycles as they were much more than the critical value of 6.0. Hence the result proved that physical, emotional, and intellectual biocycles have a significant effect on the frequencies of accidents and the accidents were occurring not by chance alone.

Table 2 Statistical comparison of actual versus expected injury frequencies for individual cycle

Cycle position	Actual		Expected
Physical			
Positive	195		210.92
Critical	66		40.16
Negative	201		210.92
Chi-square		**18.3**	
p		**P<0.05**	
Emotional			
Positive	180		214.5
Critical	51		33
Negative	231		214.5
Chi-square		**16.6**	
p		**P<0.05**	
Intellectual			
Positive	198		217
Critical	51		28
Negative	213		217
Chi-square		**20.6**	
p		**P<0.05**	

$\chi^2 = 5.99$ for df = 2 and $p < 0.05$

Table 3- Statistical comparison of actual versus expected accident frequencies by critical day combination

Critical day combination	Definition 1		Definition 2		Definition 3		Definition 4	
	Actual	**Expected**	**Actual**	**Expected**	**Actual**	**Expected**	**Actual**	**Expected**
Physical (P)	72	26	63	66	75	54	120	60
Intellectual (I)	48	34	54	43	54	54	69	48
Emotional (E)	42	51	51	67	75	87	66	77
(P)+(E)	6	3	21	12	24	15	15	13
(E)+(I)	7	4	9	18	12	24	12	21
(I)+(P)	9	5	21	12	42	23	24	18
(P)+(E)+(I)	2	0	3	3	6	6	6	5
None	276	339	240	241	174	199	150	220
Total	462	462	462	462	462	462	462	462
Chi square	**117**		**26.1**		**39.1**		**99.2**	
95% CI	**40.5%≥μ≥40.1%**		**48.2%≥μ≥47.8%**		**62.5%≥μ≥62.1%**		**67.7%≥μ≥67.3%**	

$\chi^2 = 14.1$ for df = 7 and $p < 0.05$; 95% CI = 95% Confidence Interval

Note:- Expected days rounded for ease of presentation but not for calculating the chi square statistic.

"3-day" definition is most appropriate since it is more consistent with and best reflects biorhythm theory [9, 22]. Nevertheless, in order to provide the fullest test of biorhythm theory, all four definitions were used in the present study, with expected and actual accident incidence being altered to reflect the changed number of critical days in each cycle. Actual accidents and accidents expected by chance are shown in table 3 for each critical day definition. It was found, using definition 1, 2, 3, and 4 that 40.3%, 48%, 62.3%, 67.5% of accidents were occurred on critical days of the biocycles. This percentage showed a great impact of biorhythm days on the occurrence of accidents. Definition 3 and 4 showed a greater impact in comparison of definition 1 and 2. These results confirmed the findings of Reinhold Bochow [17]. Chi square values for definition 1 was 117, for definition 2 was 26.1, for definition 3 was 39.1, and for definition 4 was 99.2. Chi-square values were significant at $p<0.05$ for all biocycles as the values were much more than the critical value of 14.1. The values of 95%CI for Definition 1 was $40.5\% \geq \mu \geq 40.1\%$, for definition 2 was $48.2\% \geq \mu \geq 47.8\%$, for definition 3 was $62.5\% \geq \mu \geq 62.1\%$, and for definition 4 was $67.7\% \geq \mu \geq 67.3\%$. Hence the calculated values of 95%CI were much more than the percentage of accidents which may be expected to occur on critical days purely by chance is 20.4%. Interestingly, the results were significant for both the chi square and 95%CI. Thus it is cleared by the definitions of critical days that critical days affect the incidence of accidents more than any other reason affected the accidents overall.

In table 4 actual and expected serious accidents were analyzed for determining whether there was a relationship between critical days definitions and occurrence of serious accidents. The results of the analysis found that value of chi square were significant ($p < 0.05$) for definition 1 and 4, and non-significant for definition 2 and 3 ($p > 0.05$) because of a less difference between the frequency of occurring and expected frequency of accidents by chance. But the value of 95%CI shows a significance of results. So, a mixed response is obtained for the occurrence of serious accidents according to the various combinations of critical days definitions.

Table 4- Statistical comparison of actual versus expected serious accident (industry standard) frequencies by critical day combination

Critical day combination	**Definition 1**		**Definition 2**		**Definition 3**		**Definition 4**	
	Actual	**Expected**	**Actual**	**Expected**	**Actual**	**Expected**	**Actual**	**Expected**
Physical (P)	14	5	12	13	15	11	26	12
Intellectual (I)	10	7	11	9	11	11	17	10
Emotional (E)	6	10	9	13	16	17	12	15
(P)+(E)	1	0.5	4	2	6	3	2	3
(E)+(I)	0	1	1	4	2	5	3	4
(I)+(P)	1	1	3	2	9	5	5	3
(P)+(E)+(I)	0	0	1	1	1	1	2	1
None	60	67.5	51	48	32	39	25	44
Total	92	92	92	92	92	92	92	92
Chi square	**19[b]**		**2.8[a]**		**5.9[b]**		**32.8[a]**	
95%CI	**$36\% \geq \mu \geq 33.5\%$**		**$45.8\% \geq \mu \geq 43.3\%$**		**$66.5\% \geq \mu \geq 64\%$**		**$74\% \geq \mu \geq 71.7\%$**	

[a] 4cells have expected frequency less than 5, $\chi^2 = 11.1$ for df = 5 and $p < 0.05$; 95% CI = 95% Confidence Interval

[b] 4cells have expected frequency less than 5, $\chi^2 = 9.49$ for df = 4 and $p < 0.05$

Note:- Expected days rounded for ease of presentation but not for calculating the chi square statistic.

Table 5 provides a statistical comparison of expected and actual frequencies of injuries as related to single and multiple critical positions for all three biocycles. The value of chi-square 69.3 was higher than the 5% significance level of 11.1 and the value of 95%CI was $35.3\% \geq \mu \geq 34.8\%$ also showed the significance of the results. This case again confirms the importance of critical days in reducing the accidents in industries.

The results of the study agree with the findings of other authors. In emphasizing the importance of critical days, Buttery [3] suggested that they are associated with an increased potential for human error and consequently with an increased likelihood of accidents. Reinhold Bochow [18] investigated only 2.2 percent of the accidents occurred on "normal days", while a startling 97.8 percent fell on critical days among agricultural workers. Another project done in the United States found that almost 70 percent of the accidents were occurred on critical days in factories [1]. Hendrick and Jones [6] reported an association between physical biorhythm and pilot error accidents and incidents. MacKenzie [12] cited the success of a Japanese railway company which reduced the number of driver accidents by 50% in a year by predicting bad days from biorhythm charts. Business enterprises have also displayed interest, and some companies have been reported to use biorhythms in an attempt to reduce accidents [8]. Such selective evidence convinced that the current findings are effective in reducing the accidents among the industrial workers.

Table 5- Statistical comparison of actual versus expected accident frequencies for critical day cycle positions

Critical day (Zero Crossing)	**Actual**	**Expected**
Physical (P)	54	35
Intellectual (I)	42	24
Emotional (E)	48	28
(P)+(E)	3	3
(E)+(I)	9	2
(I)+(P)	6	2
(P)+(E)+(I)	0	0
None	300	368
Total	462	462
Chi square	**69.28[a]**	
95%CI	**35.3%≥μ≥34.8%**	

[a] 4cells have expected frequency less than 5, $\chi^2 = 11.1$ for df = 5 and $p < 0.05$; 95% CI = 95% Confidence Interval

Conclusion

A study was undertaken to determine whether or not there was a relationship between biorhythm critical days and the incidence of industrial accidents among the industrial workers. The results obtained suggested that biorhythm critical days play a vital role in predicting the industrial accidents. In the current study critical days were measured in a variety of ways. The sequence of observed was different than might have been expected for accidents occurring randomly. It was predicted that human biological system is affected by the biocycles and the ability of human to perform a certain job changes with the change of phase of the biocycles. Level of performance was high in positive phase and decreases in the negative phase and becomes critical in critical phase of the cycle. The results of the study confirmed that biorhythm theory is important in finding the effects of critical days on industrial accidents except in the case of serious accidents because of the mixed responses of the results. Current study has an edge over the findings of Khalil and kurucz [8] for the critical day definitions. According to alternative definition fourth of critical days in table 3, 67.5% of total number of accidents falls on critical days and also 72.8% in table 4 in case of serious accidents which is higher than the other alternative definitions of the critical days. Thus, definition fourth may be used for predicting the accidents occurrence and workers may be stayed away from the hazardous work on these critical days for reducing the number of accidents in industries.

Hence, the present work suggests that biorhythm theory acts as an information system and may be implemented in the industries where chances of workers to get stuck with accidents are more. The use of biorhythm theory in preventive work connected with industrial safety in industries and strict adherence to this theory make it possible to reduce the incidence of industrial accidents and ensure safe and productive work.

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