

# Research on the influence of biological rhythm on aviation safety and safety strategy

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**Abstract**—The biorhythms were classified as physical rhythm, intellectual rhythm and emotional rhythm. Their parameters variation regular was summarized according to the origin, definition and essence, as well as the factors that can cause the deviation of biorhythm in civil aviation environment. The calculation method of biological rhythm was described, using the modern computer technology such as Excel spreadsheet programming function to build the biorhythm forecast table and the safety evaluation of civil aviation employees. The civil aviation unsafe incidents were calculated and analyzed to seek the correlation between the biorhythms and civil aviation unsafe incidents. On the basis of full consideration of biorhythm some realistic and reasonable safety strategies were put forward to reduce the incidence of civil aviation unsafe incidents.

**Keywords**—biorhythm, civil aviation safety, safety strategy

## I. INTRODUCTION

With the continuous and rapid development of China's economy, the volume of civil aviation traffic is growing rapidly. It is of great practical significance to analyze the influencing factors of unsafe events in civil aviation, take corresponding preventive measures and control measures and improve the safety level of civil aviation. In civil aviation, unsafe events are caused by unsafe behavior of people, unsafe state of things and environment. In the dynamic system composed of "people-machine- environment - management", "people" is the center. The unsafe behavior of "people" is the main cause of unsafe events in civil aviation. The proportion of human factor in causes of unsafe events in civil aviation is about 90%.

Biorhythm refers to the phenomenon of periodic life activities in accordance with certain rules in order to adapt to the changing external environment which is the basic characteristic of most organisms<sup>[1]</sup>. Medical research shows that the body's biological clock is located in the suprachiasmatic nucleus which causes people to sleep, eat, work or rest with a certain time regularity. These regularities maintain a certain approximation to the physical cycle of the region<sup>[2]</sup>. Biorhythm is preserved as a part of genetic gene so it is a special property of organism. The 2017 Nobel Prize in physiology or medicine was awarded to three American scientists (Michael w. Young, Jeffrey c. Hall, and Michael Rosbash) for their contributions to the discovery of clock genes and regulatory mechanisms<sup>[3]</sup>. This also makes the study of biological rhythms once again receive extensive

attention. Biological rhythms using in civil aviation field to prevent unsafe incidents is rare reported. This paper analyzes causes of unsafe events in civil aviation from the perspective of biological rhythms. This paper intends to use biological rhythms to predict the physiological period of civil aviation operators so as to implement humanized management in safety management and prevent the occurrence of unsafe events.

## II. BIOLOGICAL RHYTHM

In the early 20th century German doctor Wilhelm Linlis and Austrian psychologist Hermann Swarppoda discovered the physical and emotional rhythms of people. Later, professor Alinton tricher of Innsbrough university in Austria discovered the intellectual rhythm of human beings, that is, from the day of birth to the end of life, there are obvious periodic ups and downs of intelligence, emotion and physical power.

Since the day of birth, the three rhythms of physical power, emotion and intelligence show the reciprocating motion of sinusoidal function in cycles of 23 days, 28 days and 33 days respectively. Each cycle goes through a high-tide period, a critical period and a low-tide period which is shown in figure 1.

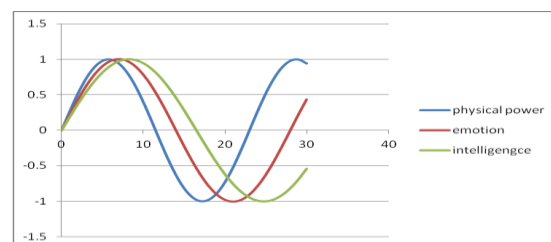


Fig.1. Changes of biorhythm cycles

### A. The physical cycle fluctuates over 23 days

The physical cycle reflects people's physical condition, disease resistance, coordination ability of various parts of the body and some changes in the speed of movement and physiology. During high-tide period the human body is energetic and responsive. During critical period human has poor stability and accident-prone. During low tide period the human body is prone to fatigue and illness and it is difficult to concentrate.

*B. The emotional cycle fluctuates over 28 days*

The emotional cycle reflects people's cooperation, creativity, sensitivity to things, emotions, mental state and people's ability to control emotions and psychology. During high tide people feel happy with high work efficiency. During critical period people are irritable. During low tide people feel low.

*C. The intelligence cycle fluctuates over 33 days*

It reflects people's memory, agility, logical thinking and analytical ability. It also reflects people's ability to accept things and deal with problems. During high tide people think quickly. People can quickly deal with emergencies. During critical period people are forgetful and slow with poor judgment. During low periods people are distracted.

High tide period is the period of energy release. The critical period is the transformation period of human function. Low tide period is the period of energy accumulation and replenishment. The transition day between high and low tide is called critical day. On critical day, the human body changes from high tide period to low tide period. At this time the various functions of the body are regulated. The energy release and accumulation process of the body interfere with each other. This's an unstable state. Not only people's coordinate ability is reduced but also mental memory and health are affected. People have low efficiency and fluctuating mood. When the critical days of two cycles or the critical days of three cycles overlap on the same day or are very close, it is more harmful to human body than the single critical day. At this time people are prone to inappropriate behavior and decision-making errors. Then unsafe events occur easily.

III. BIOLOGICAL RHYTHM CALCULATION METHOD

According to the changing laws of physical power, emotion and intelligence, formulas can be used to calculate and predict the biorhythm status of employees and provide references for work and life.

- Total number of days from birth date to test time (*M*)

$$M=365*Y+R+Z \quad (1)$$

*Y- age, the predicted year minus the year of birth*

*R- leap year number between the predicted year and the year of birth*

*Z- days remaining, the number of days between the predicted date and the current year's birthday*

- Divide the total number of days by 23, 28, and 33 respectively. Find the remainder *a*, *b*, and *c*. They correspond to physical rhythm, emotional rhythm and intellectual rhythm respectively.

$$\text{Physical rhythm: } M/23=A.....a \quad (2)$$

$$\text{Emotional rhythm: } M/28=B.....b \quad (3)$$

$$\text{intelligence rhythm: } M/33=C.....c \quad (4)$$

Combined with table I, the period of the three rhythms can be traced. The Excel can be used to predict the biological rhythm of civil aviation staff. Table II shows the example of civil aviation staff's biological rhythm.

TABLE I. BIORHYTHM QUERY TABLE

Type of biological rhythm	Biorhythmic stage		
	High tide	Critical period	Low tide
Physical rhythm(a)	2-10	0,1,11,12,22,23	13-21
Emotional rhythm(b)	2-12	0,1,13,14,15,27,28	16-26
intelligence rhythm(c)	2-15	0,1,16,17,32,33	18-31

TABLE II. EMPLOYEE BIORHYTHM PREDICTION TABLE

Name	Birth date	Forecast date	Physical rhythm stage	Intellectual rhythm stage	Emotional rhythm stage
***	21/5/1975	26/06/2019	High tide	High tide	High tide
***	07/03/1988	26/06/2019	Critical period	Critical period	High tide
***	12/12/1980	26/06/2019	Critical period	Critical period	Low tide

IV. RELATIONSHIP BETWEEN BIOLOGICAL RHYTHMS AND CIVIL AVIATION UNSAFE EVENTS

Biorhythm theory has been studied and popularized in many industries such as medical treatment, transportation, sports and mining. It has remarkable benefits in controlling accidents and ensuring safety. It can reduce the accident rate by 50% - 60%.

The samples in this paper are 583 aviation accidents of civil aviation transportation in 2018, mainly involving 1286 civil aviation employees. Table III shows the distribution of three circadian cycles of human beings of civil aviation employees involved on the day of the incident. Table IV shows the proportion of the three rhythms of civil aviation employees in each period.

TABLE III. THE DISTRIBUTION TABLE OF HUMAN BIOLOGICAL TRIAD CYCLES OF CIVIL AVIATION EMPLOYEES INVOLVED

Biological rhythm stage	High-tide period		Critical period		Low-tide period	
	Number of employee	%	Number of employee	%	Number of employee	%
Physical rhythm	234	18.18	624	48.48	429	33.33
Emotional rhythm	468	36.36	585	45.45	234	18.18
intelligence rhythm	351	27.27	701	54.55	233	18.18

According to the analysis in table V, unsafe events are prone to occur when two or three rhythms are in low tide or critical periods. In particular we should pay more attention to the time when all three rhythms are in low tide or critical periods. The data show that the proportion of employees in the three rhythms in the low or critical period in unsafe incidents is not the highest. The three low/ critical period is shorter than two low/ critical period. The average daily accident rate is high during three low/ critical period. Incident rates were lower on no critical/ low period and one critical/ low period. Biological rhythms are closely related to the occurrence of unsafe events. It is vital to prevent unsafe

incidents in civil aviation through biorhythms study.

TABLE IV. ASSESSMENT OF HUMAN BIOLOGICAL RHYTHMS OF CIVIL AVIATION EMPLOYEES INVOLVED

Evaluation of biological rhythm	Number of employees	Percentage(%)
three high tide	26	2.03
one low tide and two high tide	156	12.12
two low tide and one high tide	195	15.15
three low tide	76	5.89
one critical period two high tide	117	9.09
one low tide one critical period	195	15.15
two low tide one critical period	275	21.42
two critical period	174	13.56
one low tide two critical period	39	3.03
three critical period	33	2.55

TABLE V. CIVIL AVIATION UNSAFE INCIDENT ANALYSIS TABLE

Evaluation of biological rhythm	Three critical/low periods	Two critical/low periods	One critical/low period	No critical/low period
Number of employees involved	423	564	273	26
Percentage of employees involved	32.89%	43.96%	21.21%	2.03%

#### V. SAFETY STRATEGIES FOR PREVENTING UNSAFE EVENTS BASED ON BIORHYTHMS

Safety is the lifeblood of civil aviation. In civil aviation employees have a heavy workload. There are many unsafe factors during work. If employees are not focused enough they are prone to make mistakes and cause unsafe events. It is an effective way to use biological rhythm to assist the operation of civil aviation and to prevent unsafe incidents<sup>[4]</sup>.

##### A. Protection and warn

Collect information and draw the biorhythm chart and biorhythm curve of each employee under the guidance of relevant experts. Establish the biorhythm prediction table and set up the bulletin board of employees' biorhythm risk day. Establish three levels of risk for a person based on their biological rhythms. When one biorhythm curve is in critical period or low tide, it is a dangerous day ( the first level); when two curves are in critical period or low tide, it is a double dangerous day (the second level); when all three curves are in critical period or low tide, it is a triple dangerous day ( the third level). Each employee's monthly danger days, double danger days and triple danger days are published in the charts with different color columns to warn employees to be alert.

##### B. Safety education

By offering training courses or lectures, civil aviation managers and even every employee can understand the content of biorhythm theory and its significance to civil aviation. Safety education and training can be assisted by computer teaching, effectively combining vision and hearing,

making full use of the human body's senses to cultivate safety consciousness. At the same time, the situation simulation of unsafe events and escape protection exercises can enhance the staff's contingency handling ability. Provide proper guidance to employees. Some employees may receive hints in the critical period and generate fear, so they should get timely help to correct the negative emotions.

##### C. Work intensity control

According to the biorhythm prediction table, arrange the corresponding work tasks for employees. Treat employees in different rhythm stages in different ways. Intelligence rhythm and emotional rhythm are closely related to civil aviation safety, which should be paid special attention to. In the period of high tide of intelligence and low tide of emotion, pay attention to mediating working atmosphere to arouse the enthusiasm of work and prevent employees from being affected by the depression of emotion. In the period of low tide of intellectual rhythm and high tide of emotional rhythm, reduce the workload, prevent employees from careless and accidental injury. In the double-low period of intelligence and emotion employees are prone to fatigue and emotional fluctuations. Therefore it is necessary to strengthen supervision and education, arrange some auxiliary service measures or rest and help employees try to avoid high-risk work.

##### D. Improve working environment comfort

Biological rhythms are genetically determined but their characteristics can be influenced by internal and external factors. These factors are called timers or synchronizers. They don't create a rhythm, but they regulate the parameters of a rhythm. Light/dark, sleep/wake<sup>[5]</sup> and periodic feeding<sup>[6]</sup> are important external influences. Changing these external factors can lead to changes or disappearance of normal rhythms. Table VI shows synchronization factors and desynchronization factors affecting biological rhythms.

Civil aviation staff often suffers from jet lag or shift work due to work. They also face with problems such as loud noise, hypoxia, high and low temperature environment. The body is prone to produce adverse reactions, leading to biological rhythm disorders. The manager shall take measures to try to correct and mitigate the instability caused by these factors.

In environmental respect manager should offer a good job place that accords with ergonomics to the worker as far as possible, including appropriate temperature, humidity and brightness. The time difference can be weakened by adjusting the brightness of the light so as to improve the day-night adaptability. Light not only keeps the animal's activity cycle in line with the light-dark cycle, but also guides the phase shift of biorhythms.

TABLE VI. SYNCHRONIZATION FACTORS AND DESYNCHRONIZATION FACTORS AFFECTING BIOLOGICAL RHYTHMS

Synchronization factors	Desynchronization factors
Alternate light/dark	Daily habit disorder
Sleep/wake	Fly across time zones/ work in shifts
Trophic factors	Stimulant abuse
social environment	Noise, humidity, etc
Physical and mental activity	Physical and mental overload

Reduce temperature difference by strengthening ventilation or artificial cooling and reduce humidity difference by using dehumidification device. Above measures can reduce the harm of temperature and humidity to human body. These measures also improve efficiency.

In terms of rest, in accordance with the biological rhythm in the production process, work time and work intensity should be appropriately adjusted. Efficiency and safe work require employees to combine work with rest. Manager should set labor intensity reasonably. Civil aviation employees work too much time with high intensity. Both the brain and the body of civil aviation employees are severely fatigued. Their ability to adapt is reduced. If workload is too low employees tend to be careless and lazy. When flying across time zones a pilot's mental function is affected by the direction of the flight. For example, after crossing six time zones westward the pilot's mental function significantly decreased before and during the twilight of arrival day. After crossing six time zones eastward the pilot's mental function significantly decreased around noon of arrival day. The rest time and duration of relevant personnel should be adjusted appropriately according to the human body's rhythm changes.

To maintain normal function the body must consume a certain amount of calories and nutrients every day. The human body needs to eat regularly and follow the dietary rules. When the employees eat irregularly and are too full or hungry it will have a bad influence on the biological rhythm. When employees have too much their mood is restless, their memory is poor, their reaction time is long. After eating the body's blood is concentrated in the digestive system which leads to lack of oxygen in the brain and fatigue. If people are hungry their body will be weak and unable to complete mental work which results in hypoglycemia or dehydration and low work efficiency.

## VI. CONCLUSION

Civil aviation staff at work (especially pilots and air traffic controllers) acquire relevant information from the environment through visual, auditory, tactile and other sensory organs. Then they process (think and judge) these information by brain central organs and make corresponding actions. Problems in any of above progress may lead to unsafe events. The physical power, emotion and intelligence of civil aviation employees have a great influence on the whole aircraft operation process, that is, the biological rhythm of civil aviation staff is closely related to aviation safety.

People in the period of low physical power has low physical strength and endurance. People are also fatigable in the period of low physical power. When people are tired their reactions slow down. During low emotional periods people are absent-minded, moody, irritable and prone to worry. Employees with bad mood will lose their attention, have a weakened perception of the environment and easily miss necessary information. These will lead to unsafe events.

Civil aviation operation requires civil aviation employees to be highly focused at all times. In the period of low intelligence people's judgment ability decreases. It is difficult to choose useful information from a lot of complex information. They often cannot make the best response to the situation.

Based on the research and summary of the regularity of related parameters of biological rhythms this paper puts forward the use of excel programming function to quickly predict employees' biorhythm. According to the rhythm of the employees in the period, focus on the safety supervision and prevention measures. Our study shows that human biological rhythms do affect human behavior and are closely related to unsafe incidents in civil aviation. It is effective for preventing unsafe incidents and improving production efficiency by using biological rhythm characteristics to guide the operation of civil aviation.

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