THE EFFECTS OF THE 23-DAY AND 28-DAY BIORHYTHM CYCLES ON HUMAN PERFORMANCE

By

CURTIS LEE REAMS

Bachelor of Science in Education
Northeast Missouri State University
Kirksville, Missouri
1968

Master of Arts
Northeast Missouri State University
Kirksville, Missouri
1969

Specialist
Central Missouri State University
Warrensburg, Missouri
1970

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF EDUCATION
May, 1978

THE EFFECTS OF THE 23-DAY AND 28-DAY BIORHYTHM

CYCLES ON HUMAN PERFORMANCE

Thesis Approved:

Thesis Adviser

Dean of the Graduate College

ACKNOWLEDGMENTS

I would like to express my sincere appreciation to Dr. Aix B. Harrison, Professor, Health, Physical Education and Leisure Services, for his guidance and assistance in the preparation of this manuscript. Gratitude is also extended to the other members of my committee for their critical appraisals and encouragement. They are: Dr. Thomas A. Karman, Associate Professor and Head of Educational Administration and Higher Education; Dr. Betty Abercrombie, Professor of Health, Physical Education and Leisure Services; and Dr. John G. Bayless, Professor of Health, Physical Education and Leisure Services.

Special thanks are extended to the Oklahoma State University Library personnel for their assistance in securing a number of books and periodical articles through the inter-library loan system. A special thanks is also extended to Dr. Willard North, Director of the Computer and Research Center at Central Missouri State University, for his assistance in determining the best computer program to use and interpreting the results.

Finally, I would like to express special appreciation to my wife, Diane, and our two children, Scott and Shannon, for their sacrifice, understanding, and support which were necessary for the preparation and completion of this dissertation.

TABLE OF CONTENTS

Chapter		Page
I.	INTRODUCTION	1
	Statement of the Problem	4
	Sub-Problem of the Study	5
	Hypotheses	5
	Limitations	6
	Delimitations	6
	Assumptions	6
	Definition of Terms	7
	Description of Instruments	8
II.	REVIEW OF RELATED LITERATURE	11
	Introduction	11
	Short Term Rhythms	12
	Long Term Rhythms	15
	Biorhythm Theory Research	17
	Accidents	20
	Aviation	26
	Academic	28
	Athletics	29
	Biorhythm Calculations	33
	Research Design	34
	Summary	35
III.	METHODS AND PROCEDURES	38
	Selection of Subjects	38
	Preliminary Procedures	38
	Tests	40
	Coordination	42
	Reaction Time	44
	Static Strength	45
	Explosive Strength	45
	Muscular Endurance Assessment	46
	Muscular Endurance Test	47
	Cardiovascular-Respiratory Endurance	50
	Grouping and Analysis of Data	54
IV.	RESULTS	55
	Muscular Endurance Assessment	55

Chapter | Page

Coordination 57
Reaction Time 59
Static Strength 60
Explosive Strength 61
Muscular Endurance 62
Cardiovascular-Respiratory Endurance 63
Discussion 64
Summary 66

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS 68

Summary 68
Findings 70
Conclusions 71
Recommendations 71

SELECTED BIBLIOGRAPHY 74

APPENDIXES 78

APPENDIX A - INFORMED CONSENT FORM 79

APPENDIX B - DATA COLLECTION SHEET 81

APPENDIX C - PROCEDURES FOR CALCULATION OF BIORHYTHMS 83

APPENDIX D - LABORATORY CALCULATION SHEET 90

APPENDIX E - MUSCULAR ENDURANCE RELIABILITY MEASURES
ON 11 SUBJECTS 92

APPENDIX F - ORIGINAL DATA 94

LIST OF TABLES

Table		Page
I.	Muscular Endurance Reliability Measures on 11 Subjects	56
II.	"t" Table for Coordination--Hand Steadiness	58
III.	"t" Table for Coordination--Manipulative Dexterity	58
IV.	"t" Table for Reaction Time	59
V.	"t" Table for Static Strength--Handgrip	60
VI.	"t" Table for Explosive Strength--Standing Long Jump	61
VII.	"t" Table for Muscular Endurance	62
VIII.	"t" Table for Maximal Oxygen Consumption	63
IX.	Fine Precision Task Tests	65
X.	Gross Motor Task Tests	66
XI.	Calculation of 23-Day and 28-Day Biorhythmic Cycles	85
XII.	Figures for Month and Day of Birth	86
XIII.	Figures for Year of Birth	87
XIV.	Month and Year Selection Dates	88
XV.	Raw Data for Muscular Endurance Reliability Measures (Seconds)	93
XVI.	Raw Data for Hand Steadiness (Seconds)	95
XVII.	Raw Data for Manipulative Dexterity (Pieces)	96
XVIII.	Raw Data for Reaction Time (Seconds)	97
XIX.	Raw Data for Handgrip Strength (Pressure Pounds)	98
XX.	Raw Data for Standing Long Jump (Inches)	99

Table | Page

XXI. Raw Data for Muscular Endurance (Seconds) 100

XXII. Raw Data for Oxygen Consumption 101

LIST OF FIGURES

Figure Page

1. Determination of Test Periods--Both Rhythms in Same Phase 24 Hours and 24 Hours Prior to a Phase Change 41

2. Hand Steadiness Test 43

3. Position of Subject's Arm 62

4. Cycle Rulers 89

CHAPTER I

INTRODUCTION

A renewed interest in rhythmic functions in humans has resulted in a new theory which postulates that there are long term rhythms that govern how one performs physically, emotionally, and mentally. This theory of life rhythms has come to be known as "Biorhythms". The term biorhythm, as used today, has come to include short term rhythms as well as long term rhythms.

Many short term rhythms have been known for quite some time. The major research emphasis today has been body temperature, sleep, reaction time, coordination, heart rate, and geo-physical cycles. All are being or have been viewed in relation to their effect on humans.

Long term rhythms, until recently, have been overlooked, or neglected. New interest in long term rhythms has been generated through the publication of the book Is This Your Day? authored by George Thommen (49). Since Thommen's publication there have followed two new publications (12) (19) that focus attention to the new biorhythmic theory, and one new publication (40) that is directed toward annual rhythms.

The biorhythmic theory postulates that man fluctuates periodically from phases of high physical, mental, and emotional discharge to phases of low physical, mental, and emotional recharge, and these fluctuations are controlled by the rhythms within the body. These rhythms maintain a constant cycle and govern how one performs physically, emotionally, and mentally. Understanding of the rhythms and their cycles may help in the understanding of one's self.

The professions dealing with illnesses seem to have been the first to notice these rhythms. Two of the earliest researchers of biorhythms were Dr. Hermann Swoboda, a professor of psychology at the University of Vienna, and Dr. Wilhelm Fliess, a medical doctor in Berlin (49). These men observed that man seemed to have periodic fluctuations. Their research into illnesses identified two different rhythms of man. Thommen (49, p. 51) reports that Fleiss ascribes that the 23-day physical cycle "affects man's physical strength, endurance, resistance, and physical confidence," and the 28-day sensitivity cycle "influences creative enterprise, feelings, love, cooperation, and all coordination that is connected with the nervous system" (p. 53).

Thommen (49) also notes that after their initial work Swoboda and Fleiss continued their research along with a few other individuals; however, the possible value of biorhythms as an aid to medicine went unrecognized for years except for a few individuals.

A major reason for not recognizing the significance of biorhythms was due to the complexity of measuring a rhythm, and even today we do not have the instruments to measure a biorhythm accurately. Fleiss initially developed a mathematical formula for the study of rhythms, and through the years the formulas have been continually refined until today anyone can figure biorhythms.

At the present time, mathematics is the major means through which biorhythms are being studied. Although the rhythms are not visible to the human eye, Thommen (49) believed that the mathematic principle was clear, for he stated:

> . . . nature is ordered; order can be analyzed by mathematics; therefore, insight into nature, and particularly into the human being, can be secured by using mathematics as a probe, a tool to explore human activity. Mathematics is used in this sense as an aid or guide rather than a rule or prediction of behavior and experience (p. 10).

Gay Luce (31) stated in the book Body Time that:

> . . . people may doubt the existence of biological rhythms unless they are visible to the naked eye but until the development of high-powered microscopes they would have had to doubt the existence of cell structures and DNA. Nonetheless, until instruments with the resolving power of the electron microscope became available for the continuous study of the body's time structure, certain mathematical manipulations are the only means of making rhythms visible (p. 294).

Whether one agrees that body rhythms affect the individual or not, indications are that the rhythms exist. Oatley and Goodwin (38) state that:

> . . . whether rhythmicity is a fundamental or merely an interfering variable, in many applied situations it is clear that optimal performance or optimal experimental control will only be attained by recognizing rhythms, and cooperating with them (p. 2).

The renewal of interest in biological rhythms in man has arisen because of a new awareness that illnesses and many of man's functions seem to follow cycles (27) (31) (43). Depending upon what one is looking for, it appears that man is controlled by as many cycles as there are organs in the body (43). It then seems logical that certain rhythms would be long term rhythms in order to maintain homeostasis throughout a lifetime, and these cycles may very well influence man's total performance. Luce (31) implies in her writings on rhythms that man may come to understand and learn what Hippocrates sensed over 2,400 years ago when:

> . . . he instructed his followers that regularity was a sign of health, and that irregular body functions or habits promoted ill health. He advised them to observe closely good and bad days in their patients as well as in healthy people (p. 25).

As man learns more about the cycles, he may learn to use the rhythms to his advantage. Luce (31) summarized the importance of rhythms when she stated:

> There is no denying that they exist or that they play a formative role in our personalities and the timing of important life events, such as birth or death, and that they bias our response to danger, ability to wake, and health (p. 25).

Knowledge of biorhythms for education, physical education and athletics could be of great value. The value of such knowledge may be in their use for the scheduling of examinations, the introduction of new concepts and complex motor skills, or when to review knowledge and skills already learned. The results may lead to optimal development on a more individual basis.

The impact on athletics could lead to new programs of training and care and prevention of athletic injuries. Scheduling of individual performances and team competitions may be influenced by the highs and lows of the body's cycles.

Statement of the Problem

The problem for this study was to evaluate the validity of the biorhythmic 23-day physical cycle and 28-day sensitivity cycle, and to determine if a relationship existed between human performance and the 23-day and 28-day biorhythmic cycles with use of selected physical performance tests.

Sub-Problem of the Study

The sub-problem for this study was the development of a muscular endurance test that would be reliable and administratively economical.

Hypotheses

The hypotheses for this study, using the .05 confidence level, are as follows:

1. There will be no significant difference between cardiovascular-respiratory endurance means as measured, by the treadmill walk, during the discharge phase and recharge phase of the biorhythmic cycle.
2. There will be no significant difference between muscular endurance means as measured, by use of the cable tensiometer, during the discharge phase and recharge phase of the biorhythmic cycle.
3. There will be no significant difference between explosive strength means as measured, by use of the standing long jump, during the discharge phase and recharge phase of the biorhythmic cycle.
4. There will be no significant difference between static strength means as measured, by use of the grip dynamometer, during the discharge phase and recharge phase of the biorhythmic cycle.
5. There will be no significant difference between reaction time means as measured during the discharge phase and recharge phase of the biorhythmic cycle.
6. There will be no significant difference between coordination

means as measured, by use of a steadiness test and a peg board test, during the discharge phase and recharge phase of the biorhythmic cycle.

Limitations

1. The subjects for this study consisted of 30 Oklahoma State University male students on a volunteer basis.

2. There was no attempt to control the subjects' extracurricular activities.

Delimitations

1. This study was limited to 30 volunteer male Oklahoma State University students, between 18 and 25 years of age, during the summer term, 1976.

2. This study was limited to the 23-day physical and 28-day sensitivity cycles.

Assumptions

1. The universe has a systematic order to it and this order allows predictability on a daily, monthly, or yearly basis.

2. Man is part of the universe; therefore, under the laws of nature as man understands them, man has a systematic order.

3. Man is influenced or controlled by rhythms within the body, and these rhythms are synchronized to give order throughout life.

4. The subjects would participate in their normal extra-curricular activities with no attempt to train for improvement on the selected performance tests.

5. All subjects exerted maximum efforts on all tests.

6. The subjects would not attempt to determine their biorhythm cycles.

Definition of Terms

1. Biorhythms: The study of regulated biological life cycles. The term "cycles" may be interchanged with the word "rhythm".

2. Biorhythmic Chart: A visual sine-curve chart indicating the positions of the biorhythm cycles. It contains the days of the month which allows knowing the position of the cycles on a daily basis. The chart is divided in half with the top half being the discharge or plus phase, and the bottom half being the recharge or minus phase. The plus and minus phases are separated by the zero-line (49).

3. Zero-Line: Indicates that a cycle is changing from one phase into the other phase.

4. Critical Day: A 24-hour period in which the organism becomes unstable. It occurs during the first day of the cycle and upon changing to the recharge phase of the cycle (49).

5. Discharge Phase: The first half of the cycle, or ascending phase. The words "high" or "plus" may be used in place of discharge (49).

6. Recharge Phase: The second half of the cycle, or recuperative phase. The words "low" or "minus" may be used in place of recharge (49).

7. Period: One complete cycle of a rhythm. It may be identified in degrees, radians, time, or length in days.

8. Phase: A part or portion of a rhythm or cycle. It may be described in degrees, radians, time, or length in days.

9. 23-Day Physical Cycle: Thommen (49, p. 51) states that Fliess believed that the 23-day physical cycle "originates in the muscular cells or fibers. Its fluctuations affect man's physical strength, endurance, energy, resistance, and physical confidence."

10. 28-Day Sensitivity Cycle: Thommen (49, p. 53) states that the 28-day sensitivity cycle "governs the nervous system" and "influences creative enterprise, feelings, love, cooperation, and all coordination that is connected with the nervous system."

11. Explosive Strength: The ability to apply a force that will propel a body through space.

12. Static Strength: The exertion of a maximum force for a brief period of time against a fairly immovable object (28).

13. Reaction Time: The total time that elapses from the moment of application of a stimulus to the beginning of the resulting movement.

14. Short Term Rhythms: Rhythms that consist of 24-hour periods (circadian), or rhythms with periods shorter than 24 hours.

15. Long Term Rhythms: Rhythms that consist of periods longer than 24 hours. This may include weekly, monthly, or longer cycles.

Description of Instruments

Quinton Motorized Treadmill: An apparatus with a moving conveyor belt that may be adjusted to run at varying speeds and inclines. [Model 642, Speed Range 1.5 to 2.5 miles per hour, Elevation (percent grade) 0 to 40, Seattle, Washington.]

Physiograph: An apparatus used to monitor and record heart rate. (Type MPM-4A; Narco Bio-Systems, Inc., Houston, Texas.)

"J" Breathing Valve (One-Way): A device which allows atmospheric air to be inhaled and channels expired air into an adjacent tissot tank. (Model--Double "J" Valve; Warren E. Collins, Inc., 220 Wood Road, Braintree, Massachusetts 02184.)

Tissot Tank: A large stainless steel tank used to collect expired air during work. (Capacity--120 liters, 0 mm to 720 mm; Serial No. 1440; Warren E. Collins, Inc., 555 Huntington Avenue, Boston 15, Massachusetts.)

Kymograph: A rotating drum connected to the tissot tank from which the volume of expired air within the tank can be obtained.

Nose Clip: A device used to close off the nostrils and prevent ventilation through the nose during the collection of expired air.

Sample Bags: An expandable, rubber bag used to hold samples of a subject's expired air drawn from the tissot tank.

Pulmo-Analyzer: An instrument used to determine the percentage of oxygen and carbon dioxide contained in the samples of expired air. (Type 44A-2; Godart Instrumentation Associates, New York, New York.)

Telemetry Transmitter: A battery-powered unit used to transmit a subject's heart rate by radio waves to a receiver. (Model F.M. 1100-E2; Narco Bio-Systems, Inc., 7651 Airport Boulevard, Houston, Texas 77071.)

Telemetry Receiver: An apparatus which receives the heart rate signals conveyed by the transmitter. (Model F.M. 1100-7; Narco Bio-Systems, Inc., Houston, Texas.)

Surface Electrodes: Small discs which are placed on the skin's surface and used to transduce the electrical impulses of the heart into electric signals. (Part No. 710-0012; Narco Bio-Systems, Inc., 7651 Airport Boulevard, Houston, Texas 77017.)

Steadiness Tester: An apparatus designed to measure hand movement. (Model No. 4605C (32011); Hole Diameters--0.5, 0.312, 0.25, 0.187, 0.156, 0.125, 0.109, 0.093, 0.078 inches; Stylus Diameter--0.0625 inches; Lafayette Instrument Company, By-Pass 52 and North 9th Street Road, Lafayette, Indiana 47902.)

Clock/Counter: An apparatus in which each contact of the stylus with the steadiness tester causes a switch closure resulting in single digit increments on the front panel read out. (Model No. 54417; Time Ranges--0.1, 0.01, 0.001 seconds; Lafayette Instrument Company, By-Pass 52 and North 9th Street Road, Lafayette, Indiana 47902.)

Automatic Performance Analyzer: An instrument designed to measure movement and/or reaction by recording of time intervals. (Model 631; Time--1/100 second; Dekan Timing Devices, Glen Ellyn, Illinois.)

Grip Dynamometer: An adjustable apparatus that is hydraulically operated and measures the subject's grip strength. (Elgin Apparatus Company, Elgin, Illinois.)

Cable Tensiometer: An instrument that assesses human strength by the application of a force applied that crosses a riser on the tensiometer. (Type No. T5-6007-114-00; Tension Pounds--0 to 100; Pacific Scientific Company, Anaheim, California.)

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The growing literature indicates that rhythms are now beginning to receive greater attention. A renewed interest in rhythms developed from studies in medicine, psychiatry, flight, and safety--especially business and industrial safety. These professions have created an interest in rhythms that has resulted in their being studied through different research designs. Their findings are well characterized by the following statement: "A growing literature indicates that our performance ability is correlated with our physiological cycles and that there is a pronounced circadian rhythm in the way we perform certain tasks" (31, p. 31).

Presently there are two theories which attempt to explain how the organism can synchronize the body rhythms so precisely. The first theory states that the timing mechanism is innate. The second theory states that extrinsic factors influence the rhythms. Although neither theory can be proved, there seems to be general agreement that the main controlling mechanism is intrinsic (9) (20) (34) (41). The major disagreement is whether the main time control mechanism is influenced and synchronized by the organism itself (20) (43) (44) (52) or whether external physical factors act as the synchronizer (6) (30) (34) (41).

How the organism synchronizes the many different cycles is presently unclear. However, there does seem to be agreement that the hypothalamus and subcortical regions of the brain are the coordinating center for the synchronizing of the rhythms (6) (30) (34) (48). The dominant theory regarding the regulating of the different rhythms is the "feedback" theory, which postulates that the regulating mechanism releases or restricts the flow of energy hormones, depending upon the relationship of the organism to the environment at that particular time (36) (41).

Short Term Rhythms

Much of the research on rhythms has focused on plants and animals. Recently, research has included man as a subject. Two short term rhythms that have been studied extensively are the body temperature rhythm and the sleep/wake rhythm. Related closely to these two rhythms is the phenomenon of time lag, or "jet lag". This phenomenon is being studied because of the advanced modes of travel occurring during this era. Knowledge of these short term rhythms have increased the attention of the medical profession upon rhythms and their possible effects on man.

The temperature rhythm is one of the oldest and most reliable rhythms known. Under normal conditions the individual's body temperature peaks during the time he is awake and drops to its lowest point while sleeping (25). Palmer (39, p. 55) states that "studies show that man's mental abilities and physical dexterity vary rhythmically over a 24 hour span and coincide with his personal daily temperature curve." The individual's highest efficiency is when his body temperature is highest (41). The greatest number of errors that lead to accidents occur around 3:00 a.m., which coincides with most persons' lowest body temperature (10).

Characteristics of the sleep/wake cycle correspond closely with the body temperature cycle. As the temperature cycle goes from a high temperature to a low temperature, the sleep cycle also goes from a period of light to deep sleep and back again. One of the co-discoverers of this cycle, Nathaniel Kleitman (29, p. 54), suggested that "sleep cycles were part of a more general 'basic rest and activity cycle' (BRAC) that affected the central nervous system throughout the 24-hour day." This led to the discovery of a 90-minute cycle, which is similar to the cycle that a person goes through during sleep. During the 90-minute cycle, persons fluctuated from periods of daydreaming and fantasies to complete mental alertness (29). What is known today about the body temperature cycle and the sleep/wake cycle has implications for the areas of flight, space, medicine, psychiatry, and safety, resulting in renewed interest of the effects of these rhythms upon human performance.

Time lag, or "jet lag", has received attention due to the phenomenon of decreased performance in humans after flying between or among time zones. This is believed to be due to a phase shift in the organism's body rhythms (31) (48). With the attention now given to time lag, many companies which have executives who fly insist that they take a 24-hour rest after long flights in order to reduce errors (31). However, a 24-hour rest period would not seem to be long enough for complete readjustment (13) (48). Luce (31) and Reinberg and Ghata (41) have indicated the importance of applying these rest requirements to pilots. Based upon certain performance tests, pilot and crew performances at certain hours were as poor as if they were intoxicated (31).

Biorhythms are also of interest to space programs. These programs are interested in whether the absence from earth's physical forces would alter or damage man's rhythms. Earlier space program research has already indicated possible rhythm problems for astronauts (30) (31).

Interest in rhythms has reawakened in medicine and psychiatry. Richter (43), in his book Biological Clocks in Medicine and Psychiatry, reviewed long-term studies of periodic illnesses in man. His review indicated cycles in the somatic and mentally or emotionally ill. Luce (31) cites other specific illnesses with cycles: periodic peritonitis, cyclic psychosis, periodic catatonia, and manic-depression. Richter (43, p. 72) stated that "under various pathological conditions, man manifests many different timing devices."

There is some evidence that when surgery is to be performed or when a drug is to be administered, the body rhythms should be considered. Dr. Erhard Haus, Chairman of the Department of Anatomic and Clinical Pathology at the St. Paul-Ramsey Hospital and Medical Center in Minnesota, administered chemotherapy during the day that was the patient's peak of resistance (45). He hoped that by doing this it would "result in the maximum damage to the cancerous cells and minimum damage to the rest of the body" (45, p. 67). Thommen (49, p. 79) reports that Dr. F. Wehrli, a medical doctor in Locarno, Switzerland, stated "that he has used biorhythm mathematics in his hospital for over fifteen years . . . to ascertain the best days for elective surgery." He claims to have "performed over ten thousand operations without a single failure or complication" (49, p. 79). Furlong (18) also mentions that there may be a best time for surgery.

Regarding the administration of drugs, Klug (26) reports that William Wolf, in 1962, studied the relationship of biological rhythms and their effects on persons using certain types of medicines. He found that the same medicine may have a positive effect on the patient when given at one phase of the cycle and a negative effect when administered at a different phase of the patient's cycle.

Reinberg and Ghata (41) report that Halberg and his associates found favorable and unfavorable results when they administered drugs at different phases of a cycle. They made toxic injections of constant quantities of ouabain, a heart drug, into different lots of mice. Mice receiving overdose injections during the morning hours (8:00 a.m. to 12:00 p.m.) had a very high death rate, while those mice receiving overdose injections around midnight had a very low death rate. It might also be noted that in 1935 Judt (23) made reference to the possibility that the administration of drugs to people may be more effective during a specific phase of their cycle.

Long Term Rhythms

Recently, more attention has been given to studying the possible relationship of geophysical factors (i.e., magnetic field, moon) to medical disorders, rhythm entrainment, and psychiatric disorders. It has been discovered that illnesses, mortality rates, and psychiatric disorders correlate with some long term rhythms and geophysical forces.

Reinberg (42) notes that Halberg analyzed pneumonia and influenza deaths in 48 states of the U.S.A. There was a statistically significant circannual rhythm detected in 47 states. The greatest number of deaths occurred during the winter months of January and February for all states, irrespective of the type of climate the population lived in. Also, studies from other countries indicated the highest peak for respiratory and cardiovascular deaths during the winter months.

Although it has been ridiculed and scoffed at, other research has indicated that other forces and phenomena may influence the organism. The forces detected that seem to have an influence upon the organism are the moon, sunspot activity, and the earth's magnetic field (6) (39). All of these forces have been associated with phenomena that have affected an organism in some way.

Luce (32) tells about a group of women who charted their monthly temperature, mood, and other rhythms in order to train ovulation. This study began because Edmond Dewan, a physicist, observed a relationship between the moon and menstruation. On the fourteenth to seventeenth night of the menstrual cycle, Dewan's wife and a number of other women, slept in the light of a 100-watt lamp (artificial moon). They synchronized their bodies with the light so that ovulation usually occurred during the fourteenth to seventeenth day of their cycle. Thus, they were able to train their ovulation cycle.

Palmer (39) reported a study which found that the birthdate, thus, the conception rate, of a million children born in New York municipal hospitals, was highest during the three days around a full moon.

Another study that considered the phases of the moon was conducted by scientists at the Sandia Laboratory in New Mexico (17). They hypothesized that accidents to employees might be related to physical forces and natural phenomena. Upon analyzing employee accidents, they found a relationship between accidents and the phase of the moon in which the employees were born. They also detected a relationship between the lunar phase which was 180 degrees opposite of that in which the employees were born and employee accident susceptibility. A correlation was also found when they plotted the accidents against a 27-day cycle of disturbances in the earth's magnetic field, which correlates with the earth's rotation around the sun.

The question has also been raised as to the possibility that psychiatric disturbances are related to geophysical factors. Becker and his associates (6) reported a correlation between the daily magnetic field intensity measured at Fredricksburg, Virginia, with the daily psychiatric admission rate to two Syracuse, New York, hospitals during 1958-1961. Although the correlation was low, they felt that the results indicated a possible relationship between psychiatric disturbances and some geophysical parameter. Most of the geophysical studies are preliminary studies with much of the research in this sensitive area in process, or just underway.

Biorhythm Theory Research

Thommen (49) reports that initial research on biological cycles was started around the end of the nineteenth century by Dr. Hermann Swoboda, a professor of psychology at the University of Vienna. He "recorded the recurrence of pain and the swelling of tissue" (49, p. 14) in his patients, and concluded that cycles existed in many illnesses and even in death. His research findings led him to conclude that certain best rhythms existed in man. One rhythm was a 23-day cycle and the other a 28-day cycle. Thommen (49) sums up Swoboda's research with use of Swoboda's own words which state:

> We will no longer ask why man acts one way or another, because we have learned to recognize that his action is influenced by periodic changes and that man's reaction to an impression can be foreseen, or predicted, to use a stronger term (p. 14).

Swoboda, in searching for the origin of the 23-day and 28-day rhythms, noted that shortly after birth infants would periodically refuse to take nourishment. He concluded that digestion and absorption slowed during development of the infants' rhythms.

Dr. Swoboda's major work was his book, Das Siebenjahr (The Year of Seven), which contains his recording and analysis of rhythm development of families. He recorded family genealogies in order to verify that the relationship of the family and the major events in their lives, such as birth and death, are rhythmical. (Unfortunately, his research documentation fell into the hands of Russian troops in 1945.)

Thommen (49) also relates that Dr. Wilhelm Fleiss, a physician in Berlin, was researching rhythms he had observed in his patients. He was interested in why some children who had been exposed to an infectious disease would not catch it immediately, but later became ill. He traced illnesses, outbreak of fevers, and deaths back to the day of birth to attempt to learn the reason. While diagnosing many of his patients' illnesses and collecting a vast amount of material, he came to the conclusion that there was a 23-day and a 28-day rhythm that was basic to life. He then attributed the 23-day rhythm to the masculine inheritance and the 28-day rhythm to the feminine inheritance. Luce (31, p. 24) states that Fleiss described the 23-day rhythm as the "male component (strength, endurance, courage)," and the 28-day rhythm as the "female cycle . . . (of sensitivity, intuition, love, and other feelings)." He did not consider the menstrual cycle as part of the 28-day rhythm. Luce (31, p. 24) also noted that Fleiss asserted that: "Both cycles are present in every cell and play a dialectic role throughout life in the ups and downs of vitality, physical and mental, and eventually determine the day of one's death."

After the discovery of the 23-day physical and the 28-day sensitivity cycles by Swoboda and Fleiss, a new facet was added to the study of biorhythms. Thommen (49) reports that Dr. Alfred Teltscher, in the 1920's, wondered why students were capable of learning new materials quickly during certain periods, while during other periods they exhibited difficulty in grasping and understanding new material. Upon analyzing written reports of students he concluded that the student's intellectual performances followed a definite 33-day rhythm. This rhythm was attributed to the brain being affected by periodic secretions of the thyroid gland.

Laird (27) describes the work of Dr. Rex Hersey and associates at the University of Pennsylvania, who in 1927 were doing similar research in the United States. Everyday for two years his group kept constant records on factory workers. These records revealed that the workers were subject to alternating up and down cycles.

Later, collaborating with Dr. Michael Bennett (a medical doctor), Hersey subjected himself to a thorough physical examination every week throughout the year (47). They examined the organs and other parts of the body and established a rhythm for each. The thyroid gland, which determines the total rhythm, was found to usually complete its cycle in four to five weeks. They determined, considering all factors, that a normal cycle length was between 33 and 36 days. They continued their research by examining a greater number of other people. They concluded that there was a definite 33-day cycle, and that an active thyroid gland could cause a variance of this cycle.

The basic theory of biorhythms may best be described by Myron Stearns (47). Even though he was discussing the emotional cycle, his statement may very well apply to all cycles:

> This emotional cycle consists of an over-all up-building and giving-out of energy. But the production and use of energy do not parallel each other quite evenly. First we gradually build up more energy than we use. That makes us feel better and better, and we become more and more active and high-spirited. So we begin to use more energy than our system is producing. This keeps up until exhaustion of our surplus energy induces a reaction. We slump, often quite sharply, into feeling tired, depressed, discouraged (p. 5).

The past 30 to 40 years have resulted in a few individual researchers initiating studies involving the 23-, 28-, and 33-day rhythms. Recently, a renewed interest in the biorhythm theory has developed.

A major reason interest has increased upon the biorhythm theory is due to George Thommen's (49) book, Is This Your Day?. Prior to this book there were few studies conducted on the biorhythm theory. Since this book was published a few studies have been completed, and a number of new studies have been initiated. Interest has mounted as to whether these rhythms can and do influence human performance. Most of the early studies, up to and including today, have resulted from the attempts to reduce accidents and increase safety. Another perspective being evaluated is the possibility of predicting performance.

Accidents

Thommen (49) indicates that one of the first studies applying the 23-day, 28-day, and 33-day rhythms of life was prepared in 1939 by Hans Schwing in Zurich, Switzerland. His study actually involved two studies.

The first study involved accident cases and the second study involved deaths. The first study was based on 700 accident cases with data obtained from Swiss Insurance Companies and from the workmen's compensation board. He discovered that of the 700 accidents, 322 occurred on an individual critical day, a double critical day resulted in 74 individual accidents, and five accidents occurred on the individual's triple critical day. Of the remaining accidents, mixed rhythm days or normal days for the individual, resulted in 299 accidents. These 401 accidents on critical days represented almost 60 percent of the 700 accident cases. More importantly, these 401 accidents occurred on the individual's critical days which only comprises about 20 percent of a man's life.

The second study was based upon 300 death statistics collected from the civil records of the city of Zurich (49). Schwing used the 23-day physical and 28-day sensitivity rhythms. Out of these 300 deaths, "197 fell on critical days and the remaining 103 occurred on mixed-rhythm days" (49, p. 32), or normal days. Again, 65 percent of the deaths fell on biorhythmic critical days, and these critical days--using only the physical and sensitivity cycles--comprised approximately 15 percent of the days in a man's life.

A few years later, in 1954, Thommen (49) reports on a study by Reinhold Bochow. It involved agricultural machine accidents. Bochow also used the 23-day, 28-day, and 33-day rhythms. After studying 497 accidents, Bochow "found that 24.75 percent fell on triple critical days . . ., 46.5 percent . . . coincided with a double critical day, and 26.6 percent occurred on a single critical day" (49, pp. 32-33). He found that "only 2.2 percent of the accidents occurred on mixed-rhythm days" (49, p. 33).

In 1956, a report prepared by O. Tope and discussed by Thommen (49) was released by the city of Hannover, Germany. This report analyzed accidents to shop workers, street cleaners and truck drivers. Tope concluded that critical days were involved in 83 percent of the accidents. Thommen continues by stating that Tope declared that the driver at fault was clearly shown by the driver's biorhythm chart.

One of the early researchers in the United States was R. K. Anderson of R. K. Anderson Associates, Inc., a safety consultant firm (49). Researchers of the R. K. Anderson Associates have conducted extensive research with biorhythms in the field of safety. In one of their first studies they investigated slightly over 300 accidents in four industries in which birth dates of the individuals were available. Over a three-year period the investigation covered all accidents occurring within all four of the industries. They found "that almost 70 percent of the accidents had occurred on a critical day for the individual involved" (49, p. 36). From their earlier studies and the one cited above, they concluded:

1. There was a definite change in the individuals during the so-called 'critical' days.
2. The study of the accidents showed that the individual was unaware of this fact and could not understand why the accident occurred.
3. Critical days could be identified as to physical capabilities, mental capacity, as well as the mood of the individual (49, p. 36).

In a report issued in 1973, Anderson (2) stated that in analyzing over 1,000 accidents, 90 percent of the accidents happened on the critical day of the individual. Gittelson (19) also reported that Anderson found that:

> . . . the greatest number of accidents occurred when <u>two</u> rhythms crossed each other at baseline, or zero point, or

> just below that point. In other words, when two rhythms are moving in opposite directions and they cross when both are in critical or very close to critical, the individual appears to be violently pulled in opposite directions (p. 40).

This seemed to be when the worse accidents occurred also.

In 1965, the titanium division of N. L. Industries, after hearing lectures on biorhythms from George Thommen, introduced a biorhythm study in their rigging department and millwright shop (49). They used the pipe shop as a control group which received no guidance on their biorhythms. Foreman in the rigging and millwright shops were given biorhythmic data on the men under their supervision. The foremen then assigned men to less dangerous jobs during their critical days. This project was started when the rate of injuries was climbing throughout the factory. The results showed that "the riggers cut their injury rate 18 percent in the second half of 1965 and 42 percent during 1966" (49, p. 38), while the millwright shop cut their injury rate four percent. The pipe shop control group showed a 28 percent rise in injuries.

From these earlier studies interest developed in verifying or disproving the theory that the three rhythms affect the performance of individuals. Gittelson (19) reports that Harold Willis, aided by some students, conducted a simple laboratory-controlled experiment. They measured the physical response of reaction speed. Subjects were "asked to push a button ten times in quick succession" (19, p. 38) to measure reaction speed. They were tested five different times with their times compared to their biorhythm charts. The results indicated that:

> . . . on the average, the subjects took 5.13 seconds to push the button ten times. When their physical rhythm was in the negative phase, the time lengthened to 5.32 seconds; and when experiencing a physically critical day, the time was 5.41 seconds (19, p. 38).

In another study Neil and Sink (37), at the Man-Machine Systems Design Laboratory, Naval Postgraduate School at Monterey, California, conducted an information processing task study for a period of 70 days. The subjects consisted of male naval officers between the ages of 30 and 36 years. The apparatus used included two rows with four display panels in each row, and a response model consisting of eight buttons arranged in two rows of four buttons each. The stimulus was a digit displayed in the panels. The subjects were asked to push, as quickly as they could, the proper button on the response panel upon observing the digit (stimulus) in the display panel. Performance data was collected on reaction time, movement time, and information processing rate. The data was summitted to Fast Fourier Transforms Analysis to identify possible cycles in performance. Twelve significant harmonics were found: five on the physical cycle, two on the emotional cycle, and two on the intellectual cycle. These harmonics were all found to be within one day of the 11.5, 14.0 and 16.5 critical day of the subjects. The chance of this occurring was .015. The results of the study suggested a periodicity in performance.

The previous studies have served to instigate new studies. Some of the new studies continue to investigate the same areas of past research, while others have and are investigating different areas with different approaches and designs.

Gittelson (19) reports that Willis, in 1973, investigated 200 hospital deaths during a four-month period. He excluded all deaths of persons over 70 years of age, feeling that those records could be unreliable due to inconsistent recording procedures of that era. He used the critical day during all three cycles since he felt that "people react to the type of cycle which is most peculiar to their personality or professional field . . ." (19, p. 34). He created an extra category of "hospital effect" as hospitals today can keep people alive with machines. His results indicated that 112 people (56 percent) of the 200 cases died during a critical day. In addition, he assigned 23 death cases (12 percent) that occurred after the critical day to "hospital effect." This attributed 68 percent of the deaths to the person's critical day. Gittelson (19, p. 34) states that Willis concluded that ". . . 135 of the 200 cases of death could be linked to a critical day in each patient's cycle. Another twenty-one cases (eleven per cent) expired one day before or after a critical day." The interpretation was that 156 of the deaths, or 79 percent, occurred on or near a critical day. He did a continuation of the study with 120 cases during the summer of 1974. The same procedures and categories were used. The results indicated that:

> . . . fifty-two per cent (62 out of 120) died on critical days. Nineteen per cent (23 out of 120) died during days allotted to hospital effect, and twenty-one per cent (25 out of 120) died on the day before or after a critical day (19, pp. 34-35).

In the area of accidents, Neil and Parsons (36) conducted two studies. The first involved a Canadian Pulp Plant emphasizing the 23-day physical cycle. The data was 66 accident claims. The data was divided into two categories of "'lost time' (off the job for 24 hours or more) vs. 'non-lost-time' (no significant time away from job)" (36, p. 10). The divisions indicated that one "loss time" accident occurred in the positive phase cycle and 11 in the negative phase. Twenty-one "non-loss" time accidents occurred in the positive phase while 33 occurred in the negative phase. Analysis of the data was accomplished by use of the Chi-square statistic. The conclusion was that the negative phase resulted in the greatest number of accidents and most serious accidents. He postulated that this may be due to the organism not being able to function properly during the negative phase. He concluded that it was possible that a relationship between accidents and the physical cycle existed.

The second study by Neil and Parsons (36) involved accidents from the aircraft maintenance facility of a major airline. One hundred twenty-seven randomly selected accidents were analyzed. This study involved all three of the cycles plus the critical day. The results indicated a possible relationship between the physical and intellectual cycles and accidents. Also, analysis of the data revealed a possible relationship, in all three phases, between the critical day and accidents.

Aviation

Attention to the biorhythm theory has also focused on the area of aviation. Thommen (49) charted biorhythmic charts on pilots involved in aviation accidents. The information used was supplied by Mr. R. M. Woodham, Associate Director of the Aviation Safety Center at Cornell University. The cases indicated that the pilots' critical day was involved in about 80 percent of the accidents. There was one case where both pilot and co-pilot had identical rhythms and critical days. Mr. Woodham considered the studies interesting and, in a letter to Thommen wrote that he felt ". . . the principles were sound and recommended . . . further research" (49, p. 67). He also felt that a relationship existed between the day of an individual's accident and his biorhythm cycles.

Thommen (49) also charted rhythm positions of a few of the United States astronauts who had near mishaps during their flights. They were near, or in a critical day with at least one of the other cycles in the minus or recharge period, when an incident occurred.

In 1972, Major John Wolcott and associates (53) gathered aircraft accident cases, classified as pilot-involved, from the U. S. Army Aviation Safety Center (1,837 cases) and the National Transportation Safety Board (NTSB, 4,003 cases). The data was analyzed with the Chi-square statistical test. A significance level of 90 percent (p = 0.1) was used. Using 3,253 cases from the NTSB, single critical days of the intellectual cycle and double-critical days of the physical-intellectual cycles resulted in the occurrence of more accidents than one would expect. Despite this, statistical significance did not exist. Upon combining the NTSB and the U. S. Army data (4,279 cases) more accidents again occurred on critical days of the intellectual and emotional cycles. However, the total Chi-square value was not statistically significant. They later added data collected by Sacher in 1974, making a total of 8,625 cases. Again, the emotional and intellectual single-critical days showed more accidents occurring. The total Chi-square value was not significant.

Wolcott (53, p. 9) felt that use of the biorhythm theory was questionable since a reduction of accidents found in other studies ". . . may simply have resulted from people exercising more care as a result of individual attention." Neil (36) believed that his studies have shown that a relationship exists between human performance and the biorhythm cycles. He felt that government and private organizations should continue investigating the biorhythm theory.

Academic

Considering the variety of areas studied with use of the biorhythm theory, one would think that a few studies would be found in the area of the classroom. Surprisingly, only one study was located that involved the intellectual cycle and its relation to academic performance. Neil and associates (35) collected data from four graduate students in the Operations Research Curriculum at the Naval Postgraduate School. The data was collected for 14 months from 15 courses. The courses selected contained quantitative content only. A performance scale was developed that consisted of "categorizing performance as (a) 'well above average', (b) 'above average', (c) 'average', (d) 'below average', (e) 'well below average', and (f) 'critical'" (35, p. 12). Analysis involved use of a Chi-square statistic. Results indicated that "good" and "poor" academic performance coincided with the positive phase and negative phase, respectively, of the biorhythm cycles. The "above average" category of academic performance was found to be significant at the .001 confidence level; thus, indicating that biorhythms had an effect on "above average" performance. The "below average" academic performance did not correlate as highly with the intellectual cycle, and the hypothesis of uniformity was rejected at the .10 confidence level, leading Neil (35, p. 24) to state that "'poor' performance may represent a more 'complex' form of behavior than either 'average' or 'above average' performance." Upon conclusion of the study, it was also hypothesized that biorhythms would have an effect on performance only if the situation presented a great enough challenge to the individual.

Athletics

The area of athletics provides an ideal situation for study of the possible predictive value of biorhythm cycles and human performance. Although only a few studies have been conpleted at this time, indications are that the number will increase.

George Thommen (49), in his book, Is This Your Day?, has charted a number of athletes in golf, boxing, track, swimming, baseball, and other sports. Of the athletes charted, their performances in competition followed very closely the cyclic position of their biorhythmic chart.

Michael Wallerstein and Nancy Roberts (50) said they had developed a video-graphic technique called bio-curve display. The did not disclose how they computed a team biorhythm as they said they wanted to verify their work over a longer time period. They said that their predictions on the outcome of important past games were correct to an astonishing degree. They did reveal some of the components they considered when constructing a team biorhythm:

1. A complicated, weighted juxtaposition of player birthdates.
2. Leadership of individuals.
3. Whether many of the individuals' curves were in the positive phase, as this generated a team curve much lower than expected, or whether the curves were in a negative phase, which resulted in a more favorable team curve.
4. The direction the curves were headed on the day of play.

5: The degree of height of the three cycles seem to be an indicator of performance.

In their new undertakings, they are attempting to take into consideration the coach's bio-curve and his affect upon the team's curve or the unit he controls.

In a two-part study, Gittelson (19) states that Willis and two students conducted a study on the Missouri Southern State football team. The first part of the study called for verification of the individual player's performance in accordance to their biorhythm chart. They rated 24 backfield and end candidates on their performances. They rated them on the bases of six categories--effort, execution of task, mistakes, attitude, endurance, self-control--using a 10-point scale for each category. An overall rating was then calculated for each individual. The criteria for assignment of the point scale or to the categories was not stated. Each candidate was rated daily on his performance over a 27-day period. Each player's performance, for the 27-day period, was graphed and superimposed over his biorhythm chart. In most cases they found that the two charts closely matched each other. They then predicted the player's performance for the concluding spring practice game with about a 60 percent accuracy rate. The preliminary study was extended during the 1972 football season by Willis and Jan Case, a student (19). They charted 38 football players, for a total of 335 player/game charts. On the Thursday before each game, Case would give to the coach the predictions for each player. On Tuesday, Case would then return and pick up the coach's evaluation of each player's performance. She found that upon comparing the coach's evaluations with her biorhythm predictions that she was about 77 percent correct in her player performances predictions.

In 1973 Gary Klug (26) attempted to determine if there was a relationship between the occurrence date of an athletic injury and the biorhythmic chart position of a critical day. The population used was 6,500 Wisconsin high school students injured during the 1970-71 school year. They were members of the Wisconsin Interscholastic Athletic Association Benefit Insurance Plan. Eighty athletes were randomly chosen from the W.I.A.A. eligibility lists. The Chi-square test for significance was used. The acceptance or rejection of the hypothesis was determined by using the .05 confidence level. The results showed 17 injuries occurring on a critical day of the biorhythm cycle. Statistically, this was non-significant. This indicated that the use of biorhythms is predicting an injury to an athlete would be unreliable. However, it was also noted that 19 other injuries were recorded that occurred very near the critical day. If these injury dates were incorrectly reported, the study's statistical significance may have been affected.

In 1974, Dale Johnson (22) sought a relationship between the 23-day physical, 28-day emotional, and 33-day intellectual biorhythm cycles and injuries to varsity football players. The population consisted of 164 injured varsity players. Teams from the Western Atlantic Conference, during the 1972 intercollegiate football season, were selected. The injured players were randomly assigned by position to two groups, A or B. The groups were treated statistically by percentages and Chi-square with a selected significance level of .05. The results indicated no significant relationship between the emotional and intellectual cycles and injuries sustained. However, there was a significant relationship between the physical rhythm and football injuries by Group A, but not Group B. Also of interest is that in Group A an additional 23 injuries were sustained within one day of the individual's critical day, and in Group B there were an additional 40 injuries sustained near the critical day.

A final study was conducted by John Martin (33) in which he sought to establish whether a relationship existed between the biorhythms and official performance times of intercollegiate competitive swimmers. The population consisted of 31 college and university competitive swimmers from three institutions. Biorhythmic cycle positions were charted by use of Thommen's tables. The statistics used were a 2 x 2 and 2 x 5 Chi-square with a significance level of .05. Descriptive comparisons between the swimmers' bio-charts and their performances were also made. A biorhythm chart was divided and numbered into five windows (1 to 5). A chart was maintained for each event participated in. The swimmers' times for the season were averaged for each event. The individual time recorded for each meet was then entered in the proper numbered window. A faster time than the season's mean time resulted in that time being entered in the plus window according to the swimmer's position on the biorhythm chart. If the time was higher than the mean time, it was recorded in the negative window that corresponded with the swimmer's chart position. If two times fell in the same window, they were averaged and this average became the score recorded in the proper window. The results indicated that no statistically significant differences were indicated between performances and the physical/intellectual cycles, but a statistically significant relationship existed for group performances and the emotional cycle. Descriptive comparisons indicated frequent similarities between individual performances and the physical/ emotional rhythms. Martin's (33) conclusions were that:

1. A possible relationship existed between the physical/emotional cycles and performance.
2. Individuals reacted differently to the cycles.
3. No relationship existed between performance and the intellectual cycle.
4. No relationship existed between performance and the critical day.

The literature on rhythms would seem to indicate the existence of a relationship to human performance. Short term rhythms research has substantiated that human performance can be affected by short term rhythm oscillations.

The biorhythm theory uses as its foundation the results of the short term rhythm research, along with the earlier research establishing the three long term rhythms. The results of the research, at this point in time, would seem to indicate that human performance may be related to longer term rhythms.

Biorhythm Calculations

The basis for studying biorhythms has been mathematic calculations, and remains so today. This may be one reason why biorhythm research gained little acceptance. To figure the rhythms for any particular day was confusing and time-consuming. Swoboda had developed a slide rule to find the critical day, but he did not publicize the device (49). Fleiss, who had knowledge of mathematics, developed numerous tables to facilitate the calculations of biorhythm, but his work only confused the person reading it (49).

Thommen (49) relates that Dr. Alfred Judt, a mathematician and a doctor of engineering, was interested in studying performances of sports figures in the late 1920's. In order to compute the rhythm position of an athlete quickly he designed calculation tables. These tables established a relationship between the day and year of birth, and the day of a sports event.

Shortly after Judt had developed his tables, a Swiss engineer and mathematician, Hans Frueh, studied the available materials on biorhythms (49). To help him in his own research, he improved upon the calculation tables developed earlier. He later developed a calculator to facilitate the calculation of the rhythms. The tables developed by Judt and Frueh were the basis for all methods used today. Frueh later developed a vertical design chart that corresponded with the arrangement of his calculator and are still in use today.

A sine-curve type chart was developed during the 1950's which greatly facilitated the drawing of biorhythm charts. The sine-curve chart has made it easy for anyone to chart and understand their own rhythms, and all calculation tables have been updated through the year 1984 by George Thommen (49). There are presently a number of other biorhythm recording and charting aids available.

Research Design

Most studies dealing with the biorhythm theory have used the previously discussed methods of pre-charting these rhythms. The research designs used involve a great amount of subjectivity and generally refer to a specific segment of the period, which may result in a faulty interpretation. Reinberg (42) pointed out that physiologic functions are not a constant in time, and that other parameters must be considered when undertaking a rhythmical study. He stated that a specific design must be used that considers four parameters: "the period, τ, the acrophase, ϕ, the amplitude, A, and the mesor, M, or the rhythm-adjusted level" (42, p. 425). Also, upon identifying the parameters, additional consideration must be given to possible relationship, interference, modulation, and other factors between short-term and long-term rhythms. Reinberg (42) recommended that further studies employ longitudinal and transverse profiles (or samples) utilizing a rhythmometric approach. Furthermore, greater precision and objectivity could be achieved with use of the best fitting cosine function (least squares method), or another related method. The student's "t" test, or other statistics, was not highly recommended by Reinberg.

Two previously mentioned studies (35) (53) utilized at least one of the parameters mentioned by Reinberg (42). They attempted to ascertain the probability of a performance occurring throughout the phase of a period. In their particular studies they used the Chi-square, or a variation of the Chi-square statistic.

Summary

Basic rhythm research has been conducted and established over a long period of time. Only in the past few decades has this research focused upon man and the possible relationship of rhythms to performance. Through this focus a new theory, the Biorhythmic Theory, has emerged.

New in the sense that it advocates the supposition that three long-term rhythms influence the performance of man.

The majority of rhythm research has involved short-term rhythms. Much is now known about the rhythms of the body in relation to human performance. Two major rhythms that have been studied are the body temperature and sleep/wake rhythms. These two rhythms affect performances involved in almost any facet of life today; e.g., aviation, medicine, and accidents connected with businesses and industries.

Knowledge about the relationship of performance and short-term rhythms has recently led to investigating long-term rhythms and their possible effect upon humans. Although long-term rhythm research is still in its infancy, indications are that man is affected by them (6) (17) (27) (39) (41) (42) (43) (47).

Research related specifically to the 23-day and 28-day biorhythm theory seems to indicate a relationship between human performance and the rhythms. Of the studies cited, there were only two (26) (53) that found no relationship of performance to either one or more of the rhythms. The other research cited found a relationship between performance and one or more of the rhythms (19) (22) (33) (35) (36) (37). Further, some of the research has suggested that the direction of the rhythms may be as important as the position of the rhythms (19) (20) (23) (33) (42) (50).

Many of the early investigations of the biorhythm theory have lacked acceptable scientific methodologies and statistical analysis. Because of this it then becomes understandable why many are skeptical of the biorhythmic theory. A few of the more recent studies have attempted to overcome the lack of scientific research designs.

The public's acceptance of this theory, mainly brought about because of the publication of a few articles and books during the past decade, and made available at many book stores, should initiate new research studies on the theory. With the limited research results available that seem to favor the theory at this point in time, and the acceptance of the theory by the public, it would seem to indicate and warrant further in investigation of the biorhythm theory with accepted scientific methodologies. This paper was conducted in order to ascertain whether a relationship did or did not exist between the 23-day and 28-day biorhythm and human performance.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to determine if a relationship existed between human performance and the biorhythmic 23-day physical cycle and the 28-day sensitivity cycle by use of selected performance tests characteristic to the respective cycles. The 28-day sensitivity cycle characteristics tested were: coordination with a manipulative dexterity test and a hand steadiness test, and reaction time. The 23-day physical cycle characteristics tested were: static strength, explosive strength, muscular endurance, and cardiovascular-respiratory endurance.

Selection of Subjects

The subjects for this study consisted of 30 male students between the ages of 18 and 25 years. All subjects were volunteers from the student body at Oklahoma State University. The tests were administered during the summer session of 1976.

Preliminary Procedures

The initial meeting with the subject involved obtaining pertinent personal data needed: the subject's name, address, phone, height, and date of birth. Inquiry was made as to his present knowledge of his physical health or any known disabilities. As students at Oklahoma

State University, a physical examination record was on file with health services.

The subject was asked to wear tennis shoes and a gym suit to the exercise physiology lab located in the Colvin Physical Education Center. He was asked to maintain his regular activity and dietary habits. If he exercised daily, then he was asked to continue this, or if a non-exerciser, not to begin a program until the completion of the testing. He was also asked not to train for improvement on the tests selected for this study.

Each of the seven tests to be administered was then explained to the subject, who had an opportunity to try each one. This procedure was an attempt to relieve anxiety on the part of the subject, due to his unfamiliarity with the tests. After having become familiarized with the tests, the subject was asked to read and sign an Informed Consent Form (Appendix A).

Prior to the subject leaving the initial session, three trials of maximal arm strength with the dominant arm were obtained. These trials were recorded on the Data Collection Sheet (Appendix B). A date and time were established for a second three trials. The second three trials were obtained after allowing at least 24 hours to expire. The only criteria applied during the six trials was the time element. From these six trials, the best trial was considered to be the subject's maximal arm strength. This was needed for the muscular endurance test at the initial test period.

The subject's date of birth was used in calculating and charting the 23-day and 28-day biorhythmic cycle for the beginning of the month involved. A Cyclgraph Kit (7), which contains the tables for the calculating of the rhythms and the rulers for drawing the rhythms on the charts, was used. The procedures used in calculating the position of the rhythms are explained and outlined in Appendix C, Tables XI, XII, XIII, and XIV.

Upon completing the calculations and charting of the subject's rhythms, the testing periods were determined. The determining factor was the position of both the 23-day and 28-day rhythms. In order to test during the phases of the cycles, both rhythms had to be in the same phase of the cycle for at least 24 hours prior to testing and at least 24 hours prior to a phase change (Figure 1). The subject was not told in which phase of the cycle he was being tested, until after all testing was completed. The first time through the tests, half of the subjects were tested during the discharge phase and the other half during the recharge phase. The second test was administered when the subjects reversed their cycle phases. On the retest date, the battery of tests was administered, as nearly as possible, at the same time of day as the initial testing period. Due to uncontrollable factors, a few subjects were retested at an earlier or later time than their initial test time. However, this time did not preceed or exceed one and one-half hours of the initial test time.

Tests

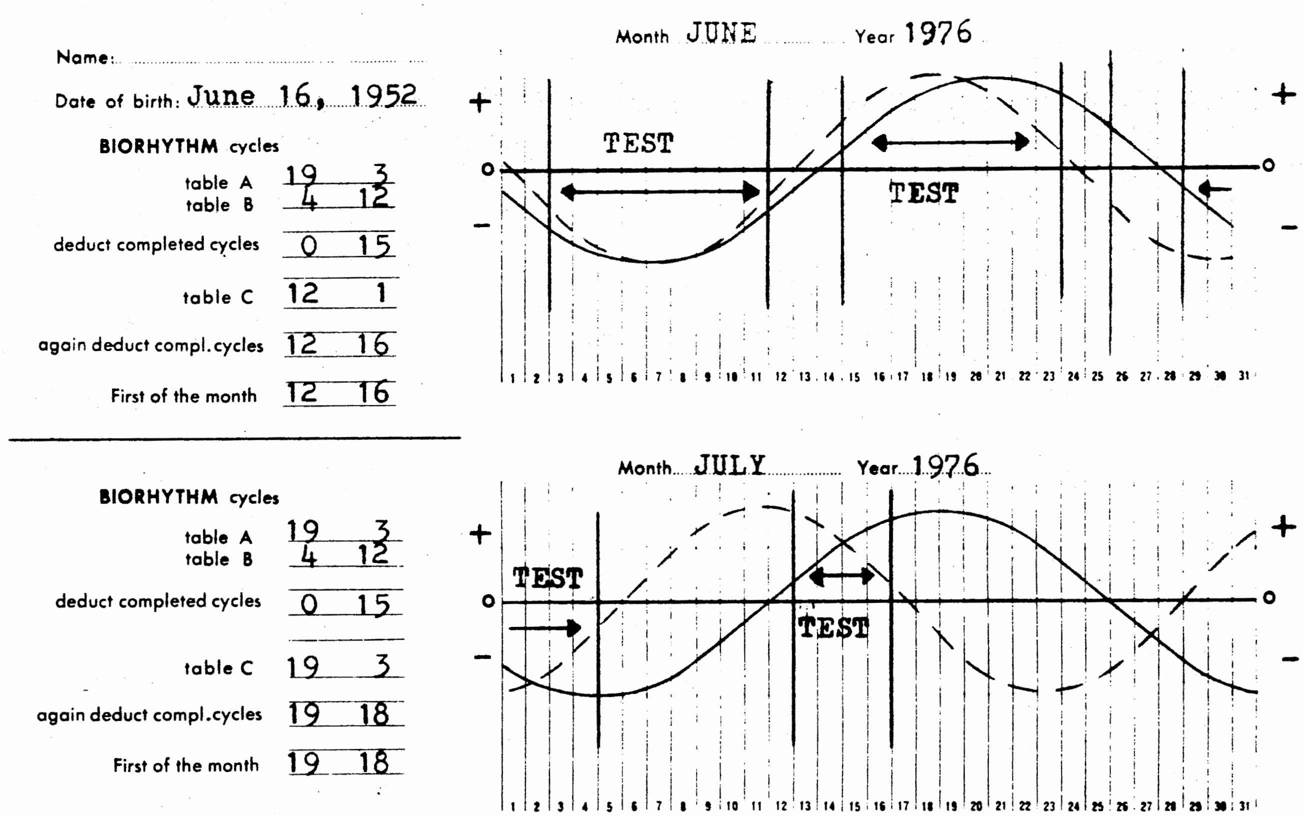
Prior to the beginning of the test periods, the subjects were weighed, and this weight recorded on the Laboratory Calculation Sheet (Appendix D).

The tests used for this study consisted of the following: hand steadiness, manipulative dexterity, reaction time, handgrip strength,

PLEASE NOTE:

Dissertation contains small
and indistinct print.
Filmed as received.

UNIVERSITY MICROFILMS.



– – – – Physical
——— Sensitivity

Source: Biorhythm Computers, Inc., Cyclgraf (1961).

Figure 1. Determination of Test Periods--Both Rhythms in Same Phase 24 Hours and 24 Hours Prior to a Phase Change

standing long jump, muscular endurance, and the treadmill walk for cardiovascular respiratory endurance.

Coordination

Testing coordination involved two separate tests. The two tests consisted of a hand steadiness test and a manipulative dexterity test.

The hand steadiness test equipment consisted of an instrument having nine holes. The holes gradually diminished in size from left to right. The hand steadiness test was connected to a timing instrument (Figure 2). Each time the stylus came in contact with the side of the holes, immediate starting of the timer took place causing single digit increments on a front panel read out. When the subject removed the metal stylus from contact with the side of the hole, the timer would stop adding the digit increments. The counter recorded the time to the thousandth of a second. By setting the counter on "run" the time recorded resulted in the total time that the stylus was in contact with all nine holes. The subject was required to hold the stylus in each hole for a time of 10 seconds. He would begin on the command of "ready", "begin". He concluded on the command of "stop". All timing was accomplished with a stop watch. The subject's score was the total time the stylus was in contact with all nine holes.

The manipulative dexterity test consisted of using the Purdue Pegboard test. The board contained two columns of 25 holes. At the top of the board there were four cups which contained pins, washers, and collars. The subject was allowed two trials with a one-minute time limit per trial. The trials were timed with a stop watch. The subject's

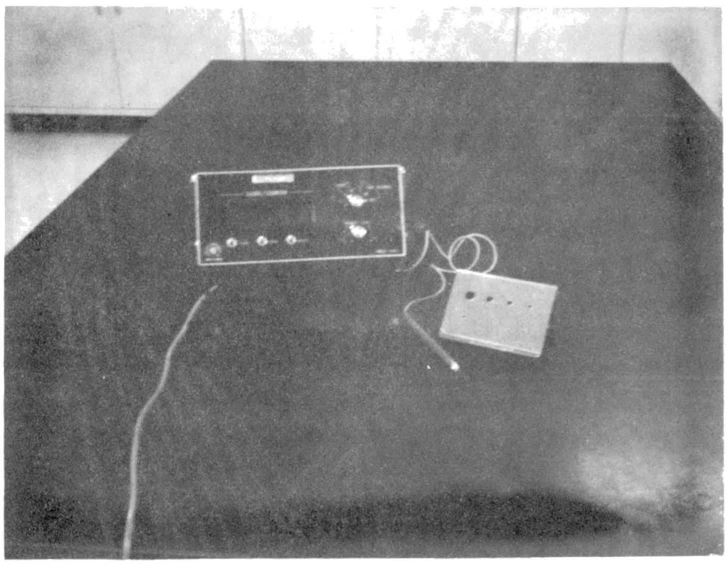


Figure 2. Hand Steadiness Test

score was the total number of components assembled in the time allotted on the highest score of the two trials.

The subject, on the command "go" assembled a pin, washer, and collar for each hole and continued this procedure until the command "stop", at which time the trial concluded. At the time of stopping, only those components on the board were counted. The subject used either all 25 holes on the right column, or all 25 holes on the left column. The subject was allowed the use of both hands simultaneously during the test. The total number of parts assembled was counted and recorded, and the second trial began. All trials were recorded with the best trial counting.

Reaction Time

The Dekan Automatic Performance Analyzer was used to measure reaction time. The stimulus used was a visual (light) stimulus. The subject was allowed five practice trials followed by 10 actual trials. The 10 trials were averaged to establish the subject's score.

The actual test involved connecting a button control cord to the analyzer. The analyzer was equipped with an automatic timer that would allow a short period of time to elapse before initiating the flash of light. This time delay could be varied so that the subject had to concentrate on the light flash for each trial. When the delay timer reached zero, the light flashed and started the automatic time clock. The subject reacted to this flash of light by depressing the button which stopped the clock. The total time elapsed, from the light flash to the time the subject depressed the button, was recorded on the automatic clock. The subject's total time to the nearest hundredth of a second was recorded for each of the 10 trials. If a time was obviously out of the normal range of other trials, that trial was discarded and another trial given.

Static Strength

The Elgin Hydraulic Grip Dynamometer was utilized for measuring static strength. The specific test used is better known as the handgrip test (28). Two trials were allowed with the best score counting. All trials were recorded.

The subject took the dynamometer in the dominant hand with the second joints of the fingers fitting snugly under the handle. It was then gripped firmly between the fingers and the palm at the base of the thumb. The arm was extended downward by the thigh. During the squeezing of the dynamometer, the arm was not allowed to swing or perform a pumping motion. However, the subject was allowed to bend his knees during the squeezing of the dynamometer. The arm and hand were not to come into contact with any other part of the body or any other object during the trial. If the preceding directions were not followed, another trial was to take place.

Explosive Strength

The standing long jump was used to measure explosive strength (28). The administration of the test took place on a flat tumbling mat with the subject wearing a non-slipping soled shoe or being barefooted. During the retest period, the subject again jumped the same as during the first testing period. The subject was permitted two attempts with the better attempt counting.

A strip of white tape was placed across the mat, at one end, for the takeoff line. The subject started with his toes behind the take-off line. The subject was instructed to maintain both feet flat on the mat (flat footed) until the moment of take-off, and both feet should take-off simultaneously. Preparatory backward swings of both arms were permitted. However, the only preparatory movement permitted for the legs was the flexing of the knees straight upward and downward in order for the feet to remain flat. Measurement of the jumps was taken from the back of the take-off line to the posterior aspect of the first heel on the mat. The mat allowed the impression of the heel to remain long enough for an accurate measurement. Should the subject fall off balance backwards, that attempt was discounted and another attempt given. The distance jumped was recorded to the nearest quarter inch.

Muscular Endurance Assessment

Reference was made, under sub-problems to this study, to the need for a muscular endurance test that would be administratively economical and reliable. It was determined that a relative endurance test would best meet the requirements for this study. This was based upon the fact that the relationship between strength and absolute endurance has been found to be high, while the relationship between strength and relative endurance was very small, thus greater assurance of endurance being measured (16).

The procedures used were based upon the study by Ahlborg *et al*. (1), with the exception of the muscle group used, the angle used, and the percent of the subject's maximum voluntary contraction force (MVC) used. This study used the bicep muscle group. The angle of pull between the top of the table and the arm was 45 degrees. The termination point for the test was 40 percent of the subject's maximum voluntary contraction.

A pilot study was conducted with this test using 11 volunteers. The test-retest procedure was used. The procedures followed are outlined under the muscular endurance test following this section. A Pearson Product-Moment correlation was used to correlate the test-retest scores. The correlation coefficient for the muscular endurance test was .91 indicating the reliability of the test and the person administering the test.

Upon completion of the pilot study, it was determined that the test would meet the requirements previously stated.

Muscular Endurance Test

Muscular endurance was measured with the use of the cable tensiometer. At the initial group session, all subjects were asked to determine their maximum strength, for the dominant arm, on two different days, three trials per day. There was a minimum of a one-day rest between the three trials. The date for the second three trials was arranged with the subject using only the criteria of 24 hours rest between test dates. On those days the subjects took three trials with the largest trial, of the six trials, taken as the maximum voluntary contraction (MVC). This maximum value was used during the actual testing periods.

The following procedures were adhered to during the actual testing period for uscular endurance. The subject was seated at a table with the posterior side of the upper arm flat on the table top. The body was square to the table with the arm in line with the direction of pull (Figure 3). The subject was directed to place the non-dominant arm in his lap or to the side. He was not allowed to apply pressure with the non-dominant arm, by either pressing against the legs, grasping the bench or the table. The cable tensiometer was secured to the bottom of the table by use of a small link chain. The chain was guided through a hole cut in the table top and connected to the tensiometer cable. The strap of the cable was placed around the wrist of the subject. The arm of the subject was rotated in order that the position desired was achieved. This position involved having the subject's palm of the dominant hand in a direct line with the shoulder (curl position). A board cut to 45 degree angles was used to position the subject's arm. The board angles were measured by the use of a goniometer to ensure that the angles were cut correctly. The reference point used for the positioning of the arm was the medial condyle of the humorous bone (Figure 3). The tensiometer operates by offsetting the cable between two sectors and crossing the cable over a riser on the tensiometer itself. When the subject applied the force (pulling), the cable stretched taut over the riser, causing a tension upon the riser. This tension was recorded on the face of the tensiometer in tension pounds.

The maximum voluntary contraction (MVC) of the subject was previously determined with the six pre-test trials. The largest trial was used for the actual testing periods. Actual testing involved the use of a proportion of the subject's MVC to determine the terminating point for the test. The proportion used for terminating the test was 40 percent of the subject's MVC. Prior to the test period, the terminating point was calculated.

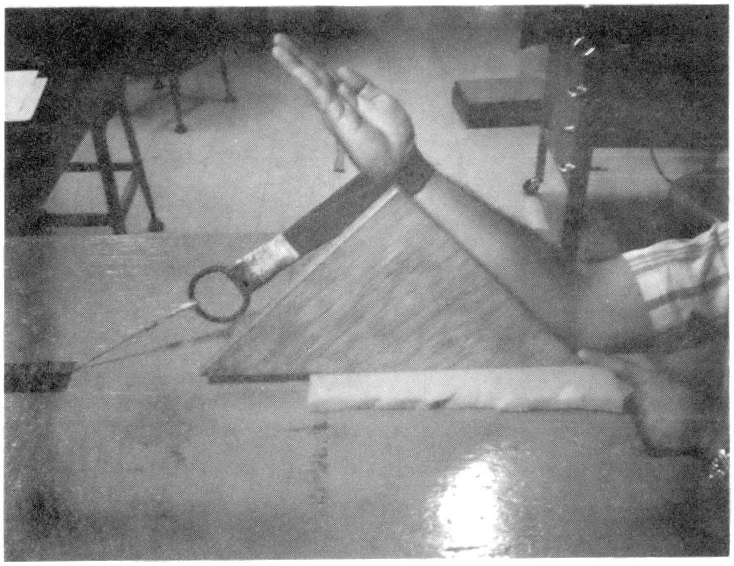


Figure 3. Position of Subject's Arm

The subject, on the command of "go", pulled against the cable strap and maintained the tension until the tensiometer dial dropped below the 40 percent figure of the MVC, at which time the test was concluded. The subject was told to apply the maximum amount of tension he was capable of throughout the trial. On the command "go", a stop watch was started. It was stopped when the subject allowed the tension to drop below 40 percent of the MVC. The score was the total time (in seconds) elapsed from the command "go" until the test was terminated. The subject was informed throughout the test of the tension he was exerting and occasionally the amount of time elapsed.

Cardiovascular-Respiratory Endurance

Cardiovascular-respiratory endurance was measured by administering a treadmill walk test, which included collecting and analyzing expired air to determine maximal oxygen consumption.

The treadmill walk test consisted of walking continuously on a motor driven treadmill at 3.4 $\pm$ .1 miles per hour. The speed remained constant, but the workload was increased by increasing the incline of the treadmill by a one percent grade each minute. The heart rate was monitored during the last 15 seconds of each minute. The target heart rate to be achieved for conclusion of the test was 180 beats per minute.

The procedures were as follows. The subject was weighed prior to any testing being started. He then removed his t-shirt and assumed a supine position to accommodate the attachment of equipment. The subject's chest was prepared for the attachment of a telemetry transmitter and surface electrodes. An alcohol prep pad was used to clean the skin at the points where the electrodes would be attached. The surface electrodes and transmitter were held in place by two-sided adhesive washers. The center of the washers was filled with an electrode cream to allow for better contact and conduction of the electrical impulses. The surface electrodes were then placed on the subject. One electrode was placed over the sternum and the other electrode placed in the V-5 position, which is approximately two inches below the left nipple and two inches to the left of the breast.

The telemetry transmitter was attached above the left breast and of equal distance between the two electrodes. The loose wires were strapped to the body to prevent excessive movement. The subject was then allowed to sit quietly for five minutes. During this time, the telemetry receiver and physiograph were prepared and adjusted for the best reception possible. The paper speed on the physiograph was set at .5 centimeters per second for recording. At the conclusion of the adjustments, a resting heart rate was recorded on the physiograph. The subject was again reminded that he could terminate the walk at any time if he felt the need to do so, and he would be told to discontinue the walk should any irregularities appear. The subject was then asked to step up to the treadmill and follow the safety precautions before starting the test. The precautions were that both handrails be grasped and run the right foot lightly along the moving belt. He then stepped onto the belt, maintaining his grasp of both handrails, and began walking. After some seconds, he was told to release the handrails and continue walking without their support. Dismounting the treadmill took place with the same procedures.

The subject began walking the treadmill with the incline at zero percent for the first minute. At the end of the first minute, the incline was raised two percent and then one percent per minute thereafter. During the last 15 seconds of each minute, the subject's heart rate was monitored. The walk concluded when the subject's heart rate reached 180 beats per minute.

At one point during the treadmill walk, a sample of the subject's expired air was taken. The subject was handed a rubber nose clip and a Collins one-way "J" breathing valve containing a rubber mouthpiece. This breathing valve was connected to a tissot tank by plastic tubing. When the subject had both pieces of equipment properly in place, expired air was collected for 30 seconds. This allowed the subject to re-familiarize himself with the procedures and to mix any gases remaining in the tissot tank from previous users. The sample of expired air was collected when the heart rate reached approximately 150 beats per minute. At the conclusion of collecting the sample of expired air, the tissot tank was emptied and made ready for the final collection. The final collection of expired air was taken when the subject's heart rate reached 180 beats per minute, and the procedures described above were followed.

Upon collecting the final air sample, the subject handed the investigator the nose clip and breathing valve, grasped both handrails, and stepped off the treadmill. The subject continued walking around the area for three to five minutes and then returned to a sitting position. His heart rate was monitored for five minutes after completion of the walk.

The analysis of the expired air was accomplished through use of the Godart pulmo-analyzer. Prior to the beginning of the testing period, the pulmo-analyzer was switched on to allow for the proper warm-up time. The pulmo-analyzer was periodically calibrated with a Lloyd gas analyzer, and daily calibrated with a gas containing known parts of oxygen and carbon dioxide. A sample of expired air was then drawn from the tissot tank with use of a rubber sample bag. The sample bag was attached to the Godart pulmo-analyzer. The air was drawn through the pulmo-analyzer and the percentage of oxygen and carbon dioxide determined. The procedures used in calculating oxygen and carbon dioxide percentage followed closely the procedures of Consolazio, Johnson and Pecora (14). Their calculation procedures were then followed by use of a Laboratory Calculation Sheet (Appendix D).

Two other elements were necessary for the computation of oxygen consumption. These two elements were the minute ventilation volume and the true oxygen value. The minute ventilation volume was determined from the kymograph attached to the tissot tank cylinder. As the expired air was collected in the tank, the cylinder rose. Attached to the kymograph was a stylus, and as the cylinder rose, the stylus recorded the 30-second volume of expired air. This volume was then multiplied by two in order to obtain the minute ventilation.

Having previously determined the percentages of oxygen and carbon dioxide, the true oxygen value could be determined by use of a line chart. The line chart was developed by Dill and Folloing and is presented in Consolazio, Johnson and Pecora (14).

Two final components needed were the barometric pressure and room temperature. These were recorded prior to extracting the sample of expired air for analysis. By use of a line chart, prepared by Robert C. Darling and presented in Consolazio, Johnson and Pecora (14), a correction factor was obtained that reduces saturated gas volumes to standard conditions, for temperature, barometric pressure, dry (STPD).

Grouping and Analysis of Data

The analysis of data required a reliable muscular endurance test that could be administered within a short period of time, and the testing of the groups for significant differences between the high and low phase means. The statistics needed for the study were the Pearson Product-Moment correlation coefficient, and t-tests to determine if there were significant differences between the means. The .05 level of confidence was used for the acceptance, or non-acceptance, of the hypotheses.

The Pearson Product-Moment correlation was used to determine the reliability of the muscular endurance test. Eleven volunteer subjects participated in the test-retest administration of the endurance test. The test-retest measurements were then correlated.

The seven tests were administered to the subjects during the high phase and low phase of the rhythms. The t-test was used to determine if there were any significant differences between the high phase mean and low phase mean of each test. The t-test was used for all hypotheses. The .05 level of confidence was used for acceptance, or non-acceptance, of the hypotheses.

The program used for the t-test was the Statistical Program for the Social Sciences (SPSS), with the analysis of the data being performed by the Central Missouri State University Computer and Research Center.

CHAPTER IV

RESULTS

The purpose of the study was to determine if a relationship existed between human performance and the biorhythmic 23-day physical and 28-day sensitivity rhythms. Thirty male, volunteer subjects participated in the study. All subjects were students at Oklahoma State University. The testing took place during the summer session, 1976.

A test to assess muscular endurance was developed and used, along with hand steadiness, manipulative dexterity, reaction time, handgrip strength, standing long jump, and the open circuit method for cardiovascular-respiratory endurance. The results of the study are presented within this chapter.

Muscular Endurance Assessment

A sub-problem for the study was the development of a test for assessing muscular endurance. A test was needed that was reliable and would not require a great amount of time to administer. The test developed was based upon procedures established in the study by Ahlborg et al. (1).

Eleven volunteer subjects were used for the pilot study. Reliability was established by the test-retest method. Three trials of the subjects' maximal voluntary contraction (MVC) were taken on one day, with three more trials taken, at least 24 hours later, on another day.

The only criteria for the six trials was the minimum elapsed time period. The best of the six trials was considered to be each subject's MVC; e.g., the subject's MVC was 40 tension pounds as registered on the tensiometer. Forty percent of the subject's MVC, 40 percent of 40, would be 16 tension pounds. The 40 percent figure was arrived at from the graph by Ahlborg et al. (1, p. 225) depicting "holding times of contractions sustained to fatigue vs. percent MVC." The test would continue as long as the subject was able to maintain a maximal contraction of 16 or more tension pounds as registered on the tensiometer. Upon the dropping of the tension pounds below 16 tension pounds, the test was terminated. The subjects were then initially tested, and after at least 24 hours, retested. The results of the pilot study are presented in Table I, with the raw data provided in Appendix E, Table XV.

TABLE I

MUSCULAR ENDURANCE RELIABILITY MEASURES ON 11 SUBJECTS

Variable	Mean	Standard Deviation	Range	r
Endurance (sec.)				
Initial	52.05	16.19	27.7-90.0	.91
Retest	50.57	14.11	33.0-85.1	

The initial test had a mean of 52.05 seconds for the muscular endurance test. The retest values averaged 50.57 seconds. A correlation between the initial and retest data, by application of the Pearson-Product Moment correlation, provided a coefficient of .91. The muscular endurance test was considered to be reliable based upon these results.

Coordination

The testing of coordination involved the use of a hand steadiness test and manipulative dexterity test. Determining if a significant difference existed between the initial high phase test mean and the low phase retest mean was accomplished by use of the "t" test. The hand steadiness test consisted of an instrument having nine holes that diminished in size. The subject inserted a stylus into each hole for a time of 10 seconds per hole. Each time the stylus came into contact with the side of the hole, the time in contact was recorded on a timing device. The subject's score was the total time that the stylus was in contact with all nine holes.

The results of hand steadiness during the high and low phases are presented in Table II, with the original data provided in Appendix F, Table XVI.

The high phase mean was 10.16 seconds while the low phase mean was 9.27 seconds. The resulting t-value of 1.12 was not significant at the .05 level of confidence, thus indicating that hand steadiness was not affected by the rhythms. However, performance was slightly better during the low phase.

The manipulative dexterity test consisted of having the subject assemble as many components as possible in one minute. The components used were pins, washers, and collars. Two trials were required. The subject's score was the highest number of components assembled of the two trials. The results of the manipulative dexterity test are presented in Table III, with the data provided in Appendix F, Table XVII.

TABLE II

"t" TABLE FOR COORDINATION--HAND STEADINESS

Phase	N	Mean (Seconds)	S.D.	S.E.M.	t	P
High	30	10.16	3.57	.80	1.12	.27
Low	30	9.27	3.70			

TABLE III

"t" TABLE FOR COORDINATION--MANIPULATIVE DEXTERITY

Phase	N	Mean (Pieces)	S.D.	S.E.M.	t	P
High	30	41.27	3.92	.96	.45	.66
Low	30	40.83	5.07			

The high phase mean of 41.27 pieces and the low phase mean of 40.83 pieces indicated very little difference between high and low phase performance. The t-value of .45 was not significant at the .05 confidence level. The manipulative dexterity test did not seem to be affected by the biorhythms.

Reaction Time

Reaction time was measured by use of the Dekan Automatic Performance Analyzer. The stimulus used for each trial was a visual (light) stimulus. The subject was allowed five practice trials followed by 10 actual trials. The 10 actual trials were averaged which established the subject's score for the high phase test period and low phase test period.

Results of the reaction time test did not agree with those who have found reaction time affected by possible rhythm fluctuation (19) (37) (43). In Table IV, the results of the reaction time tests are presented with the original data presented in Appendix F, Table XVIII.

TABLE IV

"t" TABLE FOR REACTION TIME

Phase	N	Mean (Seconds)	S.D.	S.E.M.	t	P
High	30	.169	0.02	.003	-1.79	.085
Low	30	.173	0.02			

The high phase mean of .169 seconds and low phase mean of .173 seconds indicated very little difference between the means. The t-value of -1.79 was not significant at the .05 level of confidence. It may be possible that the retesting of a few subjects, earlier or later than the initial testing time, may have affected the results of reaction time.

Static Strength

Static strength was tested by use of a hydraulically operated dynamometer. The specific test used was a grip strength test. Two trials were allowed with the best score counting. The results of the handgrip strength are presented in Table V, with the data provided in Appendix F, Table XIX.

TABLE V

"t" TABLE FOR STATIC STRENGTH--HANDGRIP

Phase	N	Mean (Pounds)	S.D.	S.E.M.	t	P
High	30	119.30	14.33	1.23	-.30	.77
Low	30	119.67	16.16			

There was no major difference between the high phase mean of 119.30 pounds of pressure and low phase mean of 119.67 pounds of pressure. The t-value of -.30 was not significant at the .05 confidence level, which would indicate that grip strength was not affected by the rhythms.

Explosive Strength

The standing long jump was used to measure explosive strength. The subject maintained both feet flat on the mat until the moment of take-off. Take-off was with both feet simultaneously. Preparatory backward swings of the arms and a flexing of the legs upward and downward were allowed. Measurement of the jumps was taken from the posterior aspect of the first heel on the mat to the back side of the take-off line. The score was recorded to the nearest quarter inch. Table VI presents the long jump results. Appendix F, Table XX, provides the essential data collected.

TABLE VI

"t" TABLE FOR EXPLOSIVE STRENGTH--STANDING LONG JUMP

Phase	N	Mean (Inches)	S.D.	S.E.M.	t	P
High	30	78.44	9.34	.69	.64	.53
Low	30	78.00	9.68			

The high phase mean averaged 78.44 inches and the low phase mean averaged 78.00 inches resulting in very little difference between the means. The resultant t-value of .64 was not of statistical significance, indicating that the rhythms did not affect explosive strength performance.

Muscular Endurance

Muscular endurance was assessed by use of a cable tensiometer. Forty percent of the subjects' MVC was used for the termination point of the test. The total amount of time the subjects' were able to maintain their MVC, before the terminating point, was recorded in seconds. The results are presented in Table VII, with the original data provided in Appendix F, Table XXI.

TABLE VII

"t" TABLE FOR MUSCULAR ENDURANCE

Phase	N	Mean (Seconds)	S.D.	S.E.M.	t	P
High	30	50.84	8.58	1.95	-.99	.33
Low	30	52.78	12.74			

There was a -1.94 difference between the high phase mean of 50.84 seconds and the low phase mean of 52.78 seconds. A -.99 t-value indicates that muscular endurance was not affected by the rhythms.

Cardiovascular-Respiratory Endurance

Cardiovascular-respiratory endurance was measured by a maximal oxygen intake capacity test. The expired air was analyzed for the percent of oxygen and carbon dioxide. The percent of oxygen and carbon dioxide, along with pressure/temperature, minute ventilation, and true oxygen, indicated the efficiency of the system during work in ml/kg/min. The results of oxygen consumption are provided in Table VIII, and the essential data presented in Appendix F, Table XXII.

TABLE VIII

"t" TABLE FOR MAXIMAL OXYGEN CONSUMPTION

Phase	N	Mean (ml/kg/min)	S.D.	S.E.M.	t	P
High	30	43.04	7.69	.89	-1.14	.26
Low	30	44.05	7.77			

Oxygen consumption during the high phase averaged 43.04 ml/kg/min, while during the low phase, oxygen consumption averaged 44.05 ml/kg/min. The resultant t-value of -1.14 was not significant at the .05 level of confidence, indicating that the rhythms seem to have no affect upon cardiovascular-respiratory endurance.

Discussion

The results of the seven tests administered during the subjects' high and low phases indicated no statistical significance at the .05 confidence level, therefore, indicating that the 23-day physical and 28-day sensitivity rhythm did not affect the performance of the subjects on the tests administered. However, reaction time was significant at the .10 level of confidence, indicating the possibility that the rhythms may have affected the subjects' performance on the test. This would be in agreement with similar studies on reaction time and speed of reaction (19) (37) (43). The possibility also exists that the retesting of a few subjects at an earlier or later time than the initial test time may have affected the subjects' performance on the reaction time test. This possibility exists since it is known that reaction time speed decreases as the individual's day progresses.

Of the seven tests administered for the study, three tests (hand steadiness, reaction time, and manipulative dexterity) could be classified as fine precision task tests. Four tests (muscular endurance, oxygen consumption, handgrip strength, and standing long jump) could be classified as gross motor task tests.

Upon studying the high and low phase means of the fine precision task tests, Table IX, it can be seen that the reaction time test and the manipulative dexterity test resulted in better performances during the high phase, while the hand steadiness test performances were better during the low phase. Although, not tested for significance, the hand steadiness and manipulative dexterity tests seem to present the possibility of a relationship existing between them. Possibly, activities requiring balance and timing may best be accomplished during the low phase of the cycle, while tasks that require speed and dexterity may best be accomplished during the high phase of the cycle.

TABLE IX

FINE PRECISION TASK TESTS

Test	Phase High	Phase Low	t	P
Hand Steadiness (seconds)	10.16	9.27	1.12	.27
Reaction Time (seconds)	.169	.173	-1.79	.085
Manipulative Dexterity (number of pieces)	41.27	40.83	.45	.66

The difference between the gross motor tasks, Table X, high and low phase means on the handgrip strength and standing long jump tests were negligible. Interesting was that better performances occurred during the low phases on the muscular endurance and oxygen consumption performances. Oxygen consumption results may be the most interesting since it is the best measurement we have for a total gross body function. Although there was only a 1.00 ml/kg/min difference between the low and high phase means, the resultant t and probability of occurrence suggest that it would be interesting to view the results of a similar test using a greater number of subjects.

TABLE X

GROSS MOTOR TASK TESTS

Test	Phase High	Phase Low	t	P
Muscular Endurance (seconds)	50.84	52.78	-.99	.33
Oxygen Consumption (ml/kg/min)	43.04	44.05	-1.14	.26
Handgrip Strength (pounds)	119.30	119.67	-.30	.77
Standing Long Jump (inches)	78.40	78.00	.64	.53

Summary

Seven tests, conducive to a laboratory environment, were chosen to evaluate effects of the 23-day physical and 28-day sensitivity rhythms on human performance. The tests were: hand steadiness, manipulative dexterity, reaction time, handgrip strength, standing long jump, muscular endurance, and oxygen consumption. Thirty male subjects participated in the study. The test-retest method was used with the resultant means being subjected to statistical analysis by use of the "t" test. The significance level of .05 was established as the level of confidence.

A test for muscular endurance was needed that would involve a short time period to administer and yet be reliable. A pilot study was administered to volunteers upon which it was established that the endurance test was reliable and that it met the time period requirement.

Results of the seven tests indicated that the physical and sensitivity rhythms had no statistically significant effect on the subjects' performances. The results of the study are in agreement with other studies (26) (53) that found no relationship of the rhythms to performance. Reaction time, however, was significant at the .10 confidence level, indicating the possibility of the rhythms affecting reaction time. The other possibility for this result may have been due to changing a few of the subjects' times for the retest period.

Viewing the seven tests in another perspective, three of the tests could be viewed as fine precision task tests and four as gross motor task tests. It was observed that a possible relationship existed between hand steadiness and manipulative dexterity. It was also noted that the oxygen consumption test resulted in better performances during the low phase of the cycle.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The past decade has resulted in the emergence of a controversial biorhythm theory. The theory implies that there are three long-term rhythms: the 23-day physical rhythm, 28-day sensitivity rhythm, and the 33-day intellectual rhythm. Through the publication of a few articles and books the public has become aware of this theory, with many believing completely in it.

The theory postulates that three long-term rhythms can influence, and some believe predict, human performance. Should the theory be found to be true, the thought of its many applications is very intriguing.

A review of the literature was undertaken in an attempt to understand underlying principles leading to the formation of the theory. The literature was also reviewed to determine whether studies on the theory had been initiated. Most of the study designs were subjective and dealt with the critical day phase. Very few studies were found that attempted to analyze the effects of the rhythms under laboratory conditions, which initiated the problem for this study.

The purpose of this study was to determine if a relationship existed between human performance and the biorhythmic 23-day physical and 28-day sensitivity rhythms within a laboratory environment. Tests were selected that were felt could be categorized to measure the characteristics associated to each respective rhythm.

The components measured were: coordination, reaction time, static strength, dynamic strength, muscular endurance, and cardiovascular-respiratory endurance. The tests selected to measure the components were: hand steadiness, manipulative dexterity, reaction time, handgrip strength, standing long jump, muscular endurance, and the open circuit method for maximal oxygen consumption (ml/kg/min).

The subjects consisted of 30 male, volunteer students enrolled at Oklahoma State University. The subjects were tested prior to the initial test period for their maximal voluntary contraction (MVC). Six trials of the subject's MVC were needed. Without regard to the rhythms, three trials were collected one day with the remaining three trials collected on another day. The only criteria for the collection of the six trials was that a minimum of 24 hours elapse between the first three trials and the second three trials. Prior to the strength testing, a muscular endurance test was developed and a pilot study administered with the test-retest method to determine reliability. The test was found to be reliable and accepted as the endurance test.

The test-retest procedure was used for the administration of the tests. Each subject was initially tested during either the high or low phase of their rhythms and retested during the opposite phase. Testing took place on any day during that phase of the rhythm, except on a critical day. The means were statistically analyzed by use of the t-test, with the results tested at the .05 level of confidence.

Findings

The findings of this study, using the .05 level of confidence, were as follows.

1. There will be no significant difference in coordination as measured during the discharge phase and recharge phase by use of a steadiness test and a peg board test.

Hypothesis one, consisting of hand steadiness and manipulative dexterity, was accepted as there was no significant difference between the discharge phase and recharge phase performance.

2. There will be no significant difference in reaction time as measured during the discharge phase and recharge phase.

Hypothesis two was accepted as no significant difference was found between the discharge and recharge phase.

3. There will be no significant difference in static strength as measured during the discharge phase and recharge phase by use of the grip dynamometer.

Hypothesis three was accepted as the handgrip strength test indicated no significant difference in performance between the discharge phase and recharge phase.

4. There will be no significant difference in explosive strength as measured during the discharge phase and recharge phase by use of the standing long jump.

Hypothesis four, finding no significant difference on the standing long jump between the discharge phase and recharge phase, was accepted.

5. There will be no significant difference in muscular endurance as measured during the discharge phase and recharge phase by use of the cable tensiometer.

Hypothesis five was accepted as no significant difference was found between the discharge and recharge phase performance.

6. There will be no significant difference in cardiovascular-respiratory endurance as measured during the discharge phase and recharge phase on the treadmill walk.

Hypothesis six, based upon the oxygen consumption test (ml/kg/min) indicating no significant difference in performance between the discharge phase and recharge phase, was accepted.

Conclusions

The results of this study do not support the majority of studies that have found a possible relationship between the rhythms and performance. Therefore, based on this study it is concluded that human performance is not affected by the rhythms postulated in the biorhythm theory.

The literature indicating a possible relationship or influence of the rhythms on performance cannot be discarded and ignored. With most studies finding a possible relationship between one or more of the rhythms and performance, it would seem appropriate that research continue to evaluate the rhythms until it becomes certain whether the rhythms do or do not influence performance.

The following conclusion is based upon the results of this study: The results of this study indicate that the 23-day physical and 28-day sensitivity rhythm had no effect on human performance.

Recommendations

Results of studies on the biorhythm theory indicate that there is a need for more research as to whether the three long term rhythms do or do not affect human performance.

The format of many of the previous studies have lacked objective procedures, tests, and research designs that allow for statistical analysis of the data. It would be highly desirable that better and more sensitive tests be developed for the detection of a rhythm. A more powerful statistical research design may be one way of achieving this detection.

A number of studies involved data pertaining to a particular phase of a rhythm, with measurements being taken once during the high phase and once during the low phase, or specifically the critical day. Since many factors could affect this type of design, such as circadian rhythms, it is suggested that some future studies employ a long term design with measurements being taken weekly or monthly. Also, short term designs covering one month to a few months time period are needed with measurements being taken daily or weekly.

The studies located involving a laboratory controlled environment were extremely lacking in number of subjects. It is strongly recommended that new research initiated, either long or short term studies, involve a greater number of subjects allowing for better statistical analysis.

It has occasionally been mentioned that rhythm direction may be significant for the evaluation of performance. This would suggest that some future research evaluate performance in relation to whether the rhythms are descending or ascending. It has also been asserted that the possibility exists that performance is affected when two or more rhythms, going in opposite directions, cross above or below and near the zero line.

Finally, the type of performance to be accomplished may be affected more by the rhythms. It is recommended that future research attempt to determine whether a precision movement performance--such as balance, dexterity, or speed of movement--is possibly affected more than a gross movement performance--such as in running or jumping.

SELECTED BIBLIOGRAPHY

1. Ahlborg, Bjorn et al. "Muscle Metabolism During Isometric Exercise Performed at Constant Force." Journal of Applied Physiology, Vol. 33, No. 2 (August, 1972), pp. 224-227.

2. Anderson, Russell K. "Biorhythm--Man's Timing Mechanism." American Society of Safety Engineers Journal, February, 1973, pp. 17-21.

3. Aschoff, Jurgen. Circadian Clocks. Amsterdam: North Holland Publishing Company, 1964.

4. Aschoff, Jurgen. "Circadian Rhythms in Man." Science, Vol. 148 (June, 1965), pp. 1427-1432.

5. Aschoff, J., M. Gatranska, and H. Giedka. "Human Circadian Rhythms in Continuous Darkness: Entrainment by Social Cues." Science, Vol. 171 (January, 1971), pp. 213-215.

6. Becker, Robert O., Charles H. Bachman, and Howard Friedman. "The Direct Current Control System: A Link Between Environment and Organism." New York State Journal of Medicine, Vol. 62 (April, 15, 1962), pp. 1169-1176.

7. Biorhythm Computers, Inc. Cyclgraf. New York: Biorhythm Computers, Inc., 1961.

8. Brown, Frank A., Jr. "The Biological Clock Problem." The Science Teacher, Vol. 31 (May, 1964), p. 35.

9. Brown, Frank A., Jr., J. Woodland Hastings, and John D. Palmer. The Biological Clock. New York: Academic Press, Inc., 1970.

10. Bryant, Samuel W. "What Jet Travel Does to Your Metabolic Clock." Fortune, Vol. 68 (November, 1963), pp. 160-163.

11. Bunning, Erwin. The Physiological Clock. New York: Springer-Verlag, 1967.

12. Cohen, Daniel. Biorhythms in Your Life. Greenwich, Conn.: Fawcett Publications, Inc., 1976.

13. Coloquhoun, W. P. Biological Rhythms and Human Performance. New York: Academic Press, 1971.

14. Consolazio, C. Frank, Robert E. Johnson, and Louis J. Pecora. Physiological Measurements of Metabolic Functions in Man. New York: McGraw-Hill Book Co., 1963.

15. Dardenne, Bob. How's Your Biorhythm Today? New York: Biorhythm Computers, Inc., n.d.

16. deVries, Herbert A. Physiology of Exercise for Physical Education and Athletics. Dubuque, Iowa: Wm. C. Brown Company Publishers, 1966.

17. Dreiske, Paul. "Are There Strange Forces in Our Lives?" Family Safety, Summer, 1972, pp. 15-16, 23.

18. Furlong, William B. "What Makes Us Tick . . . So Mysteriously?" Today's Health, May, 1971, pp. 29-31, 60-61.

19. Gittelson, Bernard. Biorhythm--a Personal Science. New York: Arco Publishing Co., Inc., 1976.

20. Harker, Janet E. The Physiology of Dirunal Rhythms. Cambridge: Cambridge University Press, 1964.

21. Johnson, Barry L., and Jack K. Nelson. Practical Measurements for Evaluation in Physical Education. Minneapolis: Burgess Publishing Company, 1969.

22. Johnson, Dale. "A Relationship of Selected Biological Rhythms to Football Injuries." (Unpub. Doctoral dissertation, University of Utah, 1974.)

23. Judt, Alfred. Arzt Und Periodenlehre (The Physician and Biorhythm). 1st Ed. Zurich: Verlag Bioritmo A. G., 1935.

24. Judt, Alfred. Biologische Rhythmen und Sportleistung (Biological Rhythm and Athletic Performance). 1st Ed. Zurich: Verlag Bioritmo A. G., 1935.

25. Kleitman, Nathaniel. "Biological Rhythms and Cycles." Physiological Reviews, Vol. 20 (January, 1949), pp. 1-30.

26. Klug, Gary A. "An Analysis of Biorhythms and Their Effect on Athletic Injuries." (Unpub. M.S. thesis, University of Wisconsin-LaCrosse, 1973.)

27. Laird, Donald A. "Are You Feeling on the Crest?" Review of Reviews, April, 1935, pp. 42-44.

28. Larson, Leonard A. Fitness, Health, and Work Capacity: International Standards for Assessment. New York: MacMillan Publishing Co., Inc., 1974.

29. Lavie, Peretz, and Daniel F. Kripke. "The 90-Minute Clock Within Us." Psychology Today, April, 1975, pp. 29-31.

30. Leonov, A. A., and V. I. Lebedev. Psychological Characteristics of the Activity of Cosmonauts. Translation of Psikhologicheskiye Osobennosti Deyatel'nostic Kosmonavtov. NASA Technical Translation, NASA TTF-727. Moscow: Nauka Press, 1971.

31. Luce, Gay G. Body Time. New York: Pantheon Books, 1971.

32. Luce, Gay Gaer. "Trust Your Body Rhythms." Psychology Today, April, 1975, pp. 52-53.

33. Martin, John Lewis. "Relationship of Selected Biological Rhythms to Performance of Competitive Swimmers." (Unpub. Doctoral dissertation, University of Utah, 1973.)

34. Mills, J. N. "Human Circadian Rhythms." Physiological Reviews, Vol. 46 (January, 1966), pp. 128-171.

35. Neil, Douglas E., Louis J. Giannotte, and Thomas A. Wyatt. Statistical Analysis of the Theory of "Biorhythms". Monterey, California: Man Machine Systems Design Laboratory, Naval Postgraduate School, n.d.

36. Neil, Douglas E. and Stuart O. Parsons. "Biorhythms--Possible Application to Flight Safety." (Paper presented at the International Air Transport Association Twentieth Technical Conference, Safety in Flight Operations.) Lockheed Aircraft, Istanbul, Turkey, November 10-15, 1975.

37. Neil, Douglas E. and Francis L. Sink. A Laboratory Design of "Biorhythms". Monterey, California: Man Machine Systems Design Laboratory, Naval Postgraduate School, 1975.

38. Oatley, Keith and Goodwin, B. C. "The Explanation and Investigation of Biological Rhythms." Biological Rhythms and Human Performance. Ed. W. P. Coloquhoun. New York: Academic Press, 1971.

39. Palmer, John D. "The Many Clocks of Man." Natural History, Vol. 79 (April, 1970), pp. 53-59.

40. Pengelley, Eric T. Circannual Clocks. New York: Academic Press, Inc., 1974.

41. Reinberg, Alain and Jean Ghata. Biological Rhythms. New York: Walker and Company, 1964.

42. Reinberg, Alain. "Aspects of Circannual Rhythms in Man." Circannual Clocks. Ed. Eric T. Pengelley. New York: Academic Press, Inc., 1974.

43. Richter, Curt P. Biological Clocks in Medicine and Psychiatry. Springfield: Charles C. Thomas Publisher, 1965.

44. Roberts, S. K. "Significance of Endocrines and Central Nervous Systems in Circadian Rhythms." Circadian Clocks. Ed. Jurgen Aschoff. Amsterdam: North Holland Publishing Co., 1964.

45. "Spring Fancy--All a Myth." U. S. News and World Report, May 17, 1976, pp. 64-67.

46. Sollberger, A. Biological Rhythm Research. New York: Elsevier Publishing Company, 1965.

47. Stearns, Myron. "Why We All Have 'Ups and Downs'." Redbook, November, 1945. Reprinted in Reader's Digest, December, 1945, pp. 4-6.

48. Strughold, Hubertus. Your Body Clock. New York: Charles Scribner's Sons, 1971.

49. Thommen, George S. Is This Your Day? New York: Crown Publishers, Inc., 1973.

50. Wallerstein, Michael R. and Nancy Lee Roberts. "All Together on the Bio-Curve." Human Behavior, April, 1973, pp. 8-15.

51. Ward, Ritchie R. The Living Clocks. New York: Alfred A. Knopf, Inc., 1971.

52. Webb, H. Marquerite and Frank A. Brown, Jr. "Timing Long-Cycle Physiological Rhythms." Physiological Reviews, Vol. 39 (January, 1959), pp. 127-161.

53. Wolcott, John H. et al. "Biorhythms--Are They a Waste of Time?" Tac Attack, November, 1975, pp. 4-9.

APPENDIXES

APPENDIX A

INFORMED CONSENT FORM

PHYSIOLOGY OF EXERCISE LABORATORY
OKLAHOMA STATE UNIVERSITY
INFORMED CONSENT FORM

Subject's Name________________________________ Date____________________

I am presently in good physical health and have no known disabilities, or restrictions on participation in activities that require physical exertion. I do have a physical examination on file with the Oklahoma State University Medical Center.

I hereby authorize Curtis Reams and/or such assistants as may be selected by him to perform the following procedure(s) and investigation(s).

A treadmill walking test to predict maximal oxygen intake capacity, an explosive strength test, static strength test, muscular endurance test, reaction time test, and two coordination tests, on

______________________________.
(Subject)

The procedure(s) and investigation(s) has (have) been explained to me by Curtis Reams or his assistant.

I understand that the procedure(s) and investigation(s) involve the following possible risks and discomforts:

All tests involve maximal exertion to achieve best performances, but should involve no unusual risk or discomfort. The treadmill test involves walking at a gradually increasing grade up to a target heart rate of 180 beats per minute. The EKG is monitored during the treadmill walk and the test is terminated upon signs of cardiac distress. The subject is free to terminate the test at any time at his own discretion.

I also understand that all test records will be kept confidential and will not be released to anyone without permission of myself or family. Test results may be tabulated for research purposes as group data and in no case will a subject's personal identity be associated with his test results without his expressed permission.

I understand that the potential benefits of the investigation are as follows:

The results of the treadmill test will give the subject a view of his current fitness status. Test results will be explained and interpreted to the subject.

Subject's Signature________________________ Witness_____________________

APPENDIX B

DATA COLLECTION SHEET

DATA COLLECTION SHEET

Subject____________________ Birthdate_______________ Height__________
Mo. Day Yr.
Address______________________________ Phone____________________________

Maximal Strength--Three Trials--Two Different Days--Best____________

Day 1 Day 2 Cycle Phase: Test Period
1____2____3____ 1____2____3____ 1____2____

HAND STEADINESS TEST: Test Period 1--Total Time _______________seconds
Test Period 2--Total Time _______________seconds

MANIPULATIVE DEXTERITY: Test Period 1--Total Pieces--Trial 1____2____Best____
Test Period 2--Total Pieces--Trial 1____2____Best____

REACTION TIME: Visual (light)--Test Period 1
Practice: 1____2____3____4____5____
Actual: 1____2____3____4____5____6____7____8____9____10____Avg.____
Test Period 2
Practice: 1____2____3____4____5____
Actual: 1____2____3____4____5____6____7____8____9____10____Avg.____

HANDGRIP: Test Period 1--Trial 1____2____Best____
Test Period 2--Trial 1____2____Best____

STANDING LONG JUMP: Test Period 1--Trial 1____2____Best____
Test Period 2--Trial 1____2____Best____

MUSCULAR ENDURANCE: Test Period 1--Total Time________________seconds
Test Period 2--Total Time________________seconds

TREADMILL WALK:
Test Period 1: Resting heart rate____b/min. Weight____
% Grade____ % O_2____ % CO_2____ O_2 Intake____ml/kg/min.

Test Period 2: Resting heart rate____b/min. Weight____
% Grade____ % O_2____ % CO_2____ O_2 Intake____ml/kg/min.

APPENDIX C

PROCEDURES FOR CALCULATION

OF BIORHYTHMS

BIORHYTHM CALCULATION STEPS

The following procedures were used in calculating the position of the biorhythms. Table XI is a summation of the explanation for charting the rhythms. The other tables are needed in order to determine the figures needed for actual calculation of the rhythms. All tables and figures follow the given explanation in this appendix.

1. Turn to Table XII and under the month and alongside the day of birth, record the figures listed, 19 and 3 (hypothetical date of birth: June 16, 1952).

2. Then, turn to Table XIII and locate the year of birth. Record the figures alongside the year of birth, 4 and 12. (People born in a leap year between March and December must deduct one day from the value shown in each cycle. Between January 1 and February 29, the values shown remain as they are.)

3. The figures from both Table XII and XIII are then added together, 23 and 15. If the totals are larger than a complete cycle, 23-day and 28-day, they are subtracted. If the totals are smaller than the completed cycle, they are carried down as is 0 and 15 (see Table XI).

4. Finally, turn to Table XIV and select the year and the month the chart is to be prepared for (June, 1976). Record the figures alongside the month, 12 and 1.

5. These figures are then added to the preceeding totals of Table XII and XIII; Table XII and XIII (0, 15) plus Table XIV (12, 1) which equals 12 and 16. Again, subtract if the totals are larger than a completed cycle, or carry down as is if smaller; carried down as is, 12 and 16 (see Table XI). The final figures, 12 and 16, indicate the position that each cycle will be as of June 1, 1976.

6. The final figures are then charted on the biorhythmic chart by use of cyclgraph rulers (Figure 4). The rulers are color coded. The red ruler is the 23-day physical cycle, and the blue ruler is the 28-day sensitivity cycle. The rulers, as well as the chart card, have the days of the month along the bottom. The preceeding final calculated figure determines which day on the ruler is placed on the first day of the chart card. The 23-day physical cycle ruler would use the figure of 12, indicating that the 12th day on the ruler would be placed over the 1st day of the month of the biorhythm chart, and the sine-curve drawn. The 28-day sensitivity ruler would use the 16th day.

TABLE XI

CALCULATION OF 23-DAY AND 28-DAY BIORHYTHMIC CYCLES

Step		Cycles	
		23-Day	28-Day
(1)	Month and Day of Birth: June 16--Table A	19	3
(2)	Year of Birth: 1952--Table B	4	12
	TOTAL	23	15
(3)	Complete Cycle:	23	28
	If total is larger--subtract If smaller--carry down as is	0	15
(4)	Month and Year Charted to: June, 1976--Table C	12	1
	TOTAL	12	16
(5)	Complete Cycle:	23	28
	If total is larger--subtract If smaller--carry down as is	12	16
	Starting Position of Cycles as of the First Day of June, 1976	12	16

TABLE XII

FIGURES FOR MONTH AND DAY OF BIRTH

Table A	June	
Date	23-Day Cycle	28-Day Cycle
1	11	18
2	10	17
3	9	16
4	8	15
5	7	14
6	6	13
7	5	12
8	4	11
9	3	10
10	2	9
11	1	8
12	0	7
13	22	6
14	21	5
15	20	4
16	19	3
17	18	2
18	17	1
19	16	0
20	15	27
21	14	26
22	13	25
23	12	24
24	11	23
25	10	22
26	9	21
27	8	20
28	7	19
29	6	18
30	5	17

Source: Biorhythm Computers, Inc., <u>Cyclgraf</u> (New York, 1961).

TABLE XIII

FIGURES FOR YEAR OF BIRTH

Table B Year Born	23-Day Cycle	28-Day Cycle
1947	14	19
1948 LY	17	18
1949	19	16
1950	22	15
1951	2	14
1952 LY	5	13
1953	7	11
1954	10	10
1955	13	9
1956 LY	16	8
1957	18	6
1958	21	5

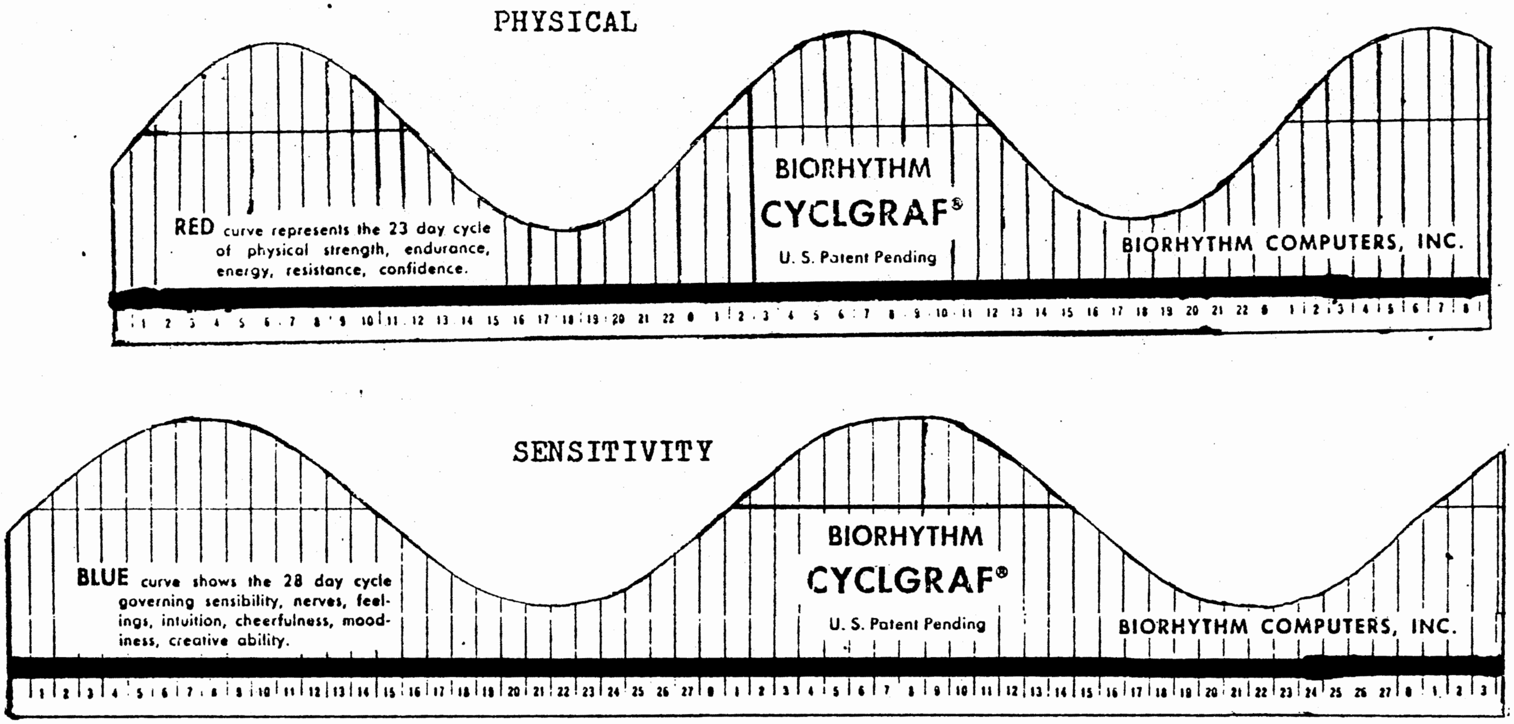
Source: Biorhythm Computers, Inc., Cyclgraf (New York, 1961).

TABLE XIV

MONTH AND YEAR SELECTION DATES

Table C Month	1976 23-Day Cycle	1976 28-Day Cycle
January	21	17
February	6	20
March	12	21
April	20	24
May	4	26
June	12	1
July	19	3
August	4	6
September	12	9
October	19	11
November	4	14
December	11	16

Source: Biorhythm Computers, Inc., Cyclgraf (New York, 1961).



Source: Biorhythm Computers, Inc., Cyclgraf (1961).

Figure 4. Cycle Rulers

APPENDIX D

LABORATORY CALCULATION SHEET

LABORATORY CALCULATION SHEET

Subject______________________________ Age______ Height________________

TEST PERIOD 1--Date________________ Weight___________

Temp.____degrees C. Barometric Pres.____mm Hg Corr. Fact.____

Rest. HR (sit)____b/min. Speed____mph Grade %____

1. O_2%____ Corr. O_2%____ CO_2%____ True O_2____
2. Vent./min. = $\frac{____}{10}$Kym mm = ____ x 1.332 = ____L/min.
3. Corr. Vent. = Vent. x Corr. Fact. = ____ x ____ = ____L/min.
4. O_2 Intake = $\frac{\text{Corr. Vent. x True } O_2}{100}$ = ____ x ____ = ____L/min.
5. Oxygen Intake ____ ml/kg/min.

TEST PERIOD 2--Date________________ Weight___________

Temp.____degrees C. Barometric Pres.____mm Hg Corr. Fact.____

Rest. HR (sit)____b/min. Speed____mph Grade %____

1. O_2%____ Corr. O_2%____ CO_2%____ True O_2____
2. Vent./min. = $\frac{____}{10}$Kym mm = ____ x 1.332 = ____L/min.
3. Corr. Vent. = Vent. x Corr. Fact. = ____ x ____ = ____L/min.
4. O_2 Intake = $\frac{\text{Corr. Vent. x True } O_2}{100}$ = ____ x ____ = ____L/min.
5. Oxygen Intake ____ ml/kg/min.

APPENDIX E

MUSCULAR ENDURANCE RELIABILITY MEASURES

ON 11 SUBJECTS

TABLE XV

RAW DATA FOR MUSCULAR ENDURANCE RELIABILITY MEASURES (SECONDS)

Subject	Test	Retest
01	66.0	51.9
02	39.8	33.0
03	44.2	43.4
04	51.9	59.0
05	27.7	34.5
06	90.0	85.1
07	56.6	46.5
08	59.9	63.0
09	43.9	46.8
10	56.9	53.1
11	35.7	40.0

APPENDIX F

ORIGINAL DATA

TABLE XVI

RAW DATA FOR HAND STEADINESS (SECONDS)

Subject	High Phase (Test)	Low Phase (Retest)
01	9.596	13.369
02	8.670	9.816
03	15.670	5.375
04	9.844	10.223
05	7.460	7.263
06	11.551	4.936
07	8.696	8.922
08	13.504	6.510
09	14.164	7.795
10	17.042	16.107
11	6.944	10.652
12	8.449	8.179
13	3.118	7.858
14	10.483	12.716
15	13.019	6.259
16	6.984	9.986
17	10.993	9.396
18	9.630	5.198
19	8.782	16.720
20	9.039	4.809
21	15.604	13.268
22	4.463	3.797
23	5.021	4.126
24	8.979	11.492
25	13.613	10.883
26	10.549	12.704
27	10.658	13.800
28	16.602	8.368
29	10.072	13.802
30	5.519	3.699

TABLE XVII

RAW DATA FOR MANIPULATIVE DEXTERITY (PIECES)

Subject	High Phase (Test)	Low Phase (Retest)
01	36	42
02	37	31
03	43	43
04	44	43
05	45	43
06	42	45
07	48	45
08	37	42
09	39	41
10	39	33
11	43	40
12	39	41
13	41	32
14	42	45
15	45	40
16	39	38
17	43	36
18	45	44
19	36	38
20	41	45
21	45	38
22	45	39
23	41	42
24	43	41
25	41	42
26	36	34
27	45	40
28	31	37
29	39	56
30	48	49

TABLE XVIII

RAW DATA FOR REACTION TIME (SECONDS)

Subject	High Phase (Test)	Low Phase (Retest)
01	.149	.146
02	.161	.169
03	.187	.193
04	.179	.168
05	.166	.164
06	.153	.143
07	.142	.158
08	.203	.203
09	.218	.219
10	.193	.174
11	.168	.168
12	.187	.172
13	.179	.210
14	.162	.185
15	.157	.171
16	.183	.191
17	.196	.217
18	.170	.172
19	.196	.202
20	.165	.155
21	.151	.157
22	.130	.138
23	.173	.146
24	.133	.171
25	.139	.157
26	.163	.170
27	.164	.161
28	.175	.173
29	.142	.154
30	.186	.203

TABLE XIX

RAW DATA FOR HANDGRIP STRENGTH (PRESSURE POUNDS)

Subject	High Phase (Test)	Low Phase (Retest)
01	168	176
02	114	106
03	108	106
04	102	100
05	120	114
06	129	128
07	130	129
08	118	120
09	127	142
10	109	114
11	135	135
12	114	105
13	114	114
14	107	105
15	97	105
16	128	128
17	140	132
18	125	135
19	111	100
20	129	122
21	115	105
22	130	133
23	115	121
24	121	119
25	104	109
26	133	130
27	115	123
28	113	126
29	105	104
30	103	105

TABLE XX

RAW DATA FOR STANDING LONG JUMP (INCHES)

Subject	High Phase (Test)	Low Phase (Retest)
01	92.75	87.25
02	74.00	71.25
03	79.00	77.75
04	72.50	69.25
05	82.00	83.25
06	64.00	66.00
07	75.75	75.75
08	91.00	91.00
09	99.00	103.00
10	61.75	67.00
11	79.25	81.00
12	79.00	76.75
13	67.00	68.50
14	74.00	74.00
15	77.75	81.00
16	71.25	78.75
17	64.50	64.00
18	95.75	93.50
19	66.25	62.25
20	81.75	80.50
21	81.00	70.50
22	84.00	85.50
23	83.00	85.75
24	77.00	68.25
25	84.00	87.00
26	86.75	84.00
27	70.75	69.75
28	74.75	75.00
29	87.75	89.00
30	76.00	73.50

TABLE XXI

RAW DATA FOR MUSCULAR ENDURANCE (SECONDS)

Subject	High Phase (Test)	Low Phase (Retest)
01	49.3	45.0
02	34.5	32.3
03	53.7	47.0
04	55.9	57.3
05	66.2	73.8
06	56.9	56.0
07	55.2	45.8
08	52.2	58.6
09	54.1	55.0
10	52.6	49.5
11	57.2	101.6
12	54.7	54.4
13	64.4	51.6
14	76.1	68.0
15	57.0	60.5
16	44.7	58.5
17	43.5	46.3
18	49.8	43.1
19	53.4	46.4
20	45.5	57.2
21	50.6	45.5
22	47.9	60.0
23	37.4	48.3
24	43.2	44.9
25	50.5	43.7
26	39.2	36.2
27	46.2	50.4
28	49.7	50.1
29	50.5	39.6
30	46.7	43.2

TABLE XXII

RAW DATA FOR OXYGEN CONSUMPTION

Subject	High Phase (Test)			Low Phase (Retest)		
	lbs	L/min	ml/kg/min	lbs	L/min	ml/kg/min
01	191	3.688	42.47	194	3.685	41.85
02	161	2.282	30.40	165	2.636	35.20
03	144	2.252	34.38	146	2.659	40.08
04	135	3.431	55.90	135	3.430	55.90
05	151	3.073	44.73	150	3.343	48.99
06	210	3.924	41.07	205	4.725	50.76
07	187	3.359	39.53	187	3.161	37.18
08	140	3.749	46.83	139	2.981	59.35
09	204	4.511	48.64	201	4.184	45.75
10	204	3.874	41.73	202	3.887	42.37
11	179	3.247	39.95	180	3.644	44.49
12	157	3.244	45.40	157	3.257	45.68
13	148	3.275	48.76	148	2.922	43.41
14	190	3.052	35.32	189	2.899	33.76
15	169	3.030	39.44	173	2.879	36.61
16	162	3.867	52.56	165	4.357	58.13
17	178	2.599	32.13	175	2.688	33.79
18	178	4.464	55.12	157	4.119	50.92
19	172	3.981	50.91	168	3.329	43.61
20	172	3.742	47.84	170	4.236	54.87
21	167	4.400	57.96	166	4.040	53.56
22	193	3.699	42.18	196	3.639	40.86
23	145	3.098	47.03	145	2.734	41.42
24	154	3.392	48.53	156	3.524	49.64
25	168	2.284	29.86	168	2.464	32.22
26	189	3.701	43.07	191	4.088	47.11
27	214	4.081	41.95	214	3.626	37.32
28	176	2.502	31.25	175	2.442	30.67
29	142	2.833	43.84	138	2.824	44.96
30	133	1.996	33.08	135	2.515	41.07

VITA 2

Curtis Lee Reams

Candidate for the Degree of

Doctor of Education

Thesis: THE EFFECTS OF THE 23-DAY AND 28-DAY BIORHYTHM CYCLES ON HUMAN PERFORMANCE

Major Field: Higher Education

Minor Field: Health, Physical Education and Recreation

Biographical:

Personal Data: Born in Des Moines, Iowa, June 16, 1946, the son of Mr. and Mrs. Melvin L. Reams. Married Diane A. Sherrard, September 5, 1965; one son, Scott, and one daughter, Shannon.

Education: Attended elementary, junior high, and high school in West Des Moines, Iowa; graduated from Valley High School in 1964; received the Bachelor of Science in Education degree from Northeast Missouri State University in 1968, with a major in Physical Education; received the Master of Arts degree in Physical Education from Northeast Missouri State University in 1969; received the Specialist degree in Physical Education from Central Missouri State University in 1970; completed the requirements for the Doctor of Education degree at Oklahoma State University in May, 1978.

Professional Experience: Served as a Graduate Teaching Assistant at Northeast Missouri State University, Kirksville, Missouri, 1968-69; served as a Graduate Teaching Assistant, Junior Varsity Baseball Coach and Assistant Gymnastics Coach at Central Missouri State University, Warrensburg, Missouri, 1969-70; served as an Instructor and Men's Gymnastic Coach at the University of Wisconsin-Stevens Point, Stevens Point, Wisconsin, 1970-71; served as an Instructor and Men's Gymnastic Coach, 1971 to present, Men's Tennis Coach, 1972 to present, Women's Gymnastic and Tennis Coach, 1976 to present, at Central Missouri State University, Warrensburg, Missouri; served as a Graduate Teaching Assistant at Oklahoma State University, 1975-76.

Professional Organizations: American Alliance for Health, Physical Education, and Recreation; American College of Sports Medicine--Central States Chapter; Missouri Association for Health, Physical Education, and Recreation; Phi Delta Kappa; Phi Epsilon Kappa National Physical Education Fraternity, National College Physical Education Association for Men; National Association of College Gymnastics Coaches.