THE ERGOGENIC EFFECT OF SELECTED MUSIC UPON PHYSICAL EFFICIENCY

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THE ERGOGENIC EFFECT OF SELECTED MUSIC UPON PHYSICAL EFFICIENCY

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DEDICATION

This thesis is respectfully dedicated
to my loving wife
SUSAN
without her hard work and constant
encouragement this thesis would have
been an impossibility

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T. L. H.

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CHAPTER I

INTRODUCTION

Music has long been recognized as influential over mind, body, and emotions,so that no longer can its existence be denied. Music is one of man's most beautiful and realistic expressions. Music has been used as an emotional arousing tool, as well as an expression of emotion.

Music today is found in some of the same activities as in ancient times, with somewhat the same goals in mind, but using a different means by which to attain it. Music has been prescribed for various ailments over the centuries, but now it is used as an adjunct to healing rather than as the primary means of casting out evil spirits.(41)

At one time General Linevitch said,

> Music is one of the most vital ammunitions of the Russian Army, without music a Russian soldier would be dull, cowardly, brutal, and inefficient . . . from the music he absorbs a magic power of endurance and forgets his suffering and mortality. It is a divine dynamite.(11)

Hungarian troops were accused of being the worst in Europe until their bands began to play, then they were the best.(5) The weird and barbaric tunes of the Cossacks, testified Napoleon, made their armies more efficient.(11)

Modern armies are no longer led to battle by the music of their bands. Now, music is used as an adjunct to ease the tension of the fighting men, as well as civilians.

The belief in the efficiency of musical magic is one of the most important facts in the history of civilization. The most important offensive weapon of magic has been the song.(8)

Purpose of the Study

It is the purpose of this study to investigate the relationship of music upon the physical efficiency of physical performance during exercise. The problem was to measure and compare the results of performance of subjects tested by the Tuttle Pulse Ratio Test while performing with and without music. There are many factors that could effect the results, but it is assumed that the study has been delimited enough to hold them to a minimum. Any marked increase in physical efficiency, therefore, may be attributed to the effects of music.

This study was designed to test the null hypothesis that music does not improve physical efficiency of human performance against the alternative hypothesis, that music, in fact, does improve physical efficiency of physical performance.

Need for the Study

Data on the effect of music upon physical efficiency is absent from the literature. In searching the literature

the author found no evidence of research in this direct area, although much was found in related areas.

Within recent years many athletic teams have used music in the locker room and on the field with no scientific evidence to support its use, except for the observation of the coaching staff, team physician, and trainer. From the results of this study it is hoped that there will be significant indication to warrant the use of music as an ergogenic aid in the field of physical education, athletics, and in any related field that it is applicable.

Delimits

Undoubtedly there are physiological and psychological responses to music and some interrelationships between both of them, but in this study only the physiological response of physical efficiency will be dealt with.

Limitations of the Study

This study is limited in the following ways:

Sample

1. The number of subjects were limited to a total of eighteen men in the age range of 23 to 40 years old.
2. The subjects were limited in that they were all male graduate students in physical education at Michigan State University, East Lansing, Michigan.

Technique and Procedure

1. A recording of John Philip Sousa's "Stars and Strips Forever" at 120 beats per minute was the only music used.

2. Motivation and attitude were not controlled.

There are several limitations in this study. The author realizes this and assumes they have been held to a minimum in order that significant conclusions may be the results of this experiment.

Definitions

Ergogenic Aid

An assistance to improve performance or hasten recovery.(39) One or several of the following possibilities may be involved. They are:

1. Direct action upon the muscle fiber.
2. Counteraction of fatigue products.
3. Additional supply of fuel needed for muscular contraction.
4. Effects the heart and circulatory system, increasing their efficiency and thus facilitating the transport of oxygen, fuel and waste.
5. Effects the respiratory center.
6. Delays the onset of feeling of fatigue by action on the nervous system.

Physical Efficiency

A measure of cardio-vascular response to exercise.

$$\frac{100(\text{Number of steps required for a 2.5 pulse ratio})}{50}$$

Pulse Ratio

The ratio of the resting pulse rate to the pulse rate after exercise.

2.5 Pulse Ratio

This is an empirical value. This ratio may be obtained by the majority of individuals by moderate amounts of exercise while being tested by the Tuttle Pulse Ratio Test.

Number of Steps for a 2.5 Pulse Ratio

$$\text{\# of steps first exercise} + \frac{(\text{\# of steps second exercise} - \text{\# of steps first exercise after first exercise})\,(2.5 - \text{Pulse Ratio after first exercise})}{\text{Pulse Ratio after second exercise} - \text{Pulse Ratio after first exercise}}$$

CHAPTER II

REVIEW OF THE LITERATURE

Studies related to the field of human response to music have been extensively reviewed in the literature. The previous research that was reviewed was divided into five categories as it pertains to music. The following categories will be reviewed:

1. Physiological response of humans and animals to music.
2. Emotional response to music.
3. Response to music by humans to different types of music.
4. Physical performance and the effect of music.
5. Effect of music on factory production.

Physiology

Respiration

The pioneer in the investigation of the influence of music on respiration was Dogiel (13) in 1880. He found in his research that music did accelerate the rate of respiration. Diserens (11), Ellis and Brighouse (16) found similar results. Weld (50) and Guibaud (21) found that music accelerated respiration, but that it decreased the regularity of respiration. In contrast, Foster and Gamble (18), found that music stimuli does not markedly affect the regularity of respiration. Also, they concluded that

listening to music, loud or soft, major or minor, tends to shorten the expiratory pause, and to make the breathing faster and shallower.

Binet and Coutier (4) investigated the effect of music on respiration and pulse beat and found that consonant and dissonant chords, major and minor intervals, and changes in the intensity of the music all produced changes of the pulse and respiration. Binet and Coutier (3) in another study, investigated only the influence of musical stimuli on respiration. These sensorial stimuli produced no modification except an acceleration of from 0.5 to 3.5 additional respiration per minute. The acceleration varied directly with the livelyness of the movement.

In response to acoustic stimulation, Corbeille and Baldes (9), found human beings in response to the unexpected sounding of an electric automobile horn, breathing at a faster, deeper and irregular rate. Laird (31) found the breathing of frogs is slowed by relatively pure acoustic stimuli when the tones are prolonged. When the stimuli was repeated over and over again, a faster rate of breathing was found. With mammalian forms of life, all acoustic stimuli produced faster and shallower breathing.

Oxygen Consumption

Oxygen, in an adequate supply, is necessary in order to carry on life and normal activity. Oxygen is used by all cells for oxidative functions in the metabolic changes

from which energy is derived. When more energy is required, metabolism increases, and thus the need for oxygen increases.

Karpovich (27) states the factors in determining the rate of oxygen intake are:

1. Ventilation of the lungs, with lung ventilation increasing proportionately to the increase in the load of work.
2. Oxygen carrying capacity of the blood.
3. Unloading of oxygen at the tissue.
4. Minute volume of the heart.

These factors must be properly coordinated and integrated with work of the muscles if the body is to attain its highest efficiency.

Krestovnikoff (30) found in his study using music with exercise that oxygen consumption increased slightly. Participants in the study reported that they found it easier to exercise with the music rather than without it. He concluded that suitable music acts as an additional reinforcing stimulus which compels participants to work more energetically, although there was an increase in energy used, work becomes easier.

Tarchanoff (44) in a study involving dogs and guinea pigs, found that they consumed more oxygen and eliminated more carbondioxyide when they were subjected to the influence of music.

Metabolism

In reference to the effect of music on metabolism, Mathews (32) found that music stimulated all bodily processes and had a decided physical and chemical reaction upon the body, increasing metabolism. Dutto (15) found similar evidence that music increases metabolism. Tarchanoff (44) was in agreement with these findings.

Cardiovascular

Hyde (24) in studying the effects of different kinds of musical selections upon the cardiovascular system in individuals of different degrees of musical background and appreciation, concluded that cardiovascular functions can be modified by music. There was a wide variance among his subjects.

Tarchanoff (43), in his study on the medical effects of music, found that music exerts a definite influence upon the circulatory system, occasionally on the heart beat, and at times an alteration of the blood pressure.

Sears (41) measured the vascular changes in the capillaries of her subjects and found changes in the movement of blood in the capillaries occurring when music was played.

Coutts (10) experimented on the effect of music on pulse rate with the subjects riding a bicycle ergometer to fast, slow, and no music. He concluded that there is no significant after effect on pulse rate or speed of the bicycle ride.

Muscles

Johnson (25) in a study involving the use of music as it relates to physical education found the strength of contraction increases with the intensity of the sound. Also, the effect of music upon muscular contraction is greatly increased by any sound made simultaneously with the movement. Music can increase the strength of contraction and greatly postpone fatigue. Diserens (11) found similar results that the influence of music tends to reduce or delay fatigue and thus increase muscular endurance. He also found that music increased the extent of muscular reflexes.

Féré (17), Sripture (40), and Tarchanoff (42) all found in their studies that isolated tones, scales, motifs, and simple tonal sequences have an energizing effect upon the muscles.

Gaston (19), in his study of mood changes effected by music found that music, stimulates muscular action.

Emotions

> Music produces like effects on the mind as good medicine on the body.
> --Mirandola

In a study involving hypnotized subjects, Warthin (48), investigated the effect of hypnotism while listening to music. He found the first effect of music was always an emotional one. The physiologic changes that followed were partly the direct outcome of these emotions, and partly the

result of the secondary experience. He also found that if music was listened to intently, a state of self induced hypnosis would become apparent.

Galvanic Skin Response

Dreher (14), Henkin (23), and Phazes (35) all found in their studies that the physiological response to music designed as exciting, neutral, and calming exist in that order on a scale of Galvanic Skin Response, with the magnitude of the score inversely related to resistance. Zimny (51) also studied three types of music designed as exciting, neutral, and calming. The Galvanic response to exciting music was a pronounced decrease in resistance indicating increased emotional arousal, while the response to both neutral and calming music remained unchanged throughout the playing of the music.

Music

Type

Podolsky (36), in his study on "Physical Effects of Music," found that different types of music had different effects on his subjects. Sad melodies accelerated respiration and diminished the amplitude of respiration. From the sad melodies he introduced the military march to his subjects, which also accelerated respiration, but showed less tendency to reduce amplitude. He concluded that music produces measurable physiological effects upon the body's functions.

Gilliland and Moore (20), in another study on the type of music and the reaction of the subject to the music, found that jazz music tended to increase the rate of the heart to a greater extent than classical music. They repeated their study and found that this relationship held true.

During a study on the effects of music on fatigue, Tarchanoff (44) found that gay music of rapid movement causes fatigue to vanish for a variable time. The opposite effect was produced with sad slow music in the minor key.

Keer (29) while studying the effect of music on factory production concluded that music of a moderate or peppy tempo produced the greatest work output.

Rhythm

Washco (49) studied the effect of a large variety of musical compositions upon organic processes. He states that, "the raising or lowering of the pulse rate and blood pressure depends upon the type of music used. A certain type of music is associated with a definite physiological response." His results show the greatest increase in pulse rate and blood pressure occurred with Sousa's "Stars and Stripes Forever," which he found to be rhythmically dominant. Washco's results points out that the more rhythmic or melodic the composition, the more certain and effective the physiologic response.

In an investigation of the principles of aesthetics, Parker (34) concluded that

> man has a tendency to follow rhythmical sounds with his muscles, hands, feet, heart, and respiratory apparatus. Even when he doesn't move visually in unison he tends to do so, which proves that in any case the motor mechanism of the body is stimulated and brought into play by the sounds.

He goes on to state, "there is a direct psychophysical connection between the hearing of rhythmic sounds and the tendency to execute certain movements."

Schoen (39) feels that rhythm is started on its course by some muscular contraction. There is a tendency to group experiences through movements of varying intensities.

> Psychologically whenever we are presented with a succession of sensory experiences we at once tend to organize them, bring them together into a unit. Consciousness is rhythmic, that is, orderly. In chaos there is discomfort.

In a study by Mikol (33) on the effect of music and rhythm on performance,he made the assumption that rhythm is probably facilitative for its aids the organization of material into functional units, thus giving accent to certain phases of response and making them stand out as reference points. He concluded that when a regular, reoccurring sound is clear, definite, and synchronous with the motion required for optimal performance of a paced repetitive task, it tends to have a facilitative effect.

Rennholm (38) investigated mechanical efficiency and found that through rhythm a definite physiological savings could be achieved in the activity of lifting.

Physical Performance

In an experiment to find the value of music to physical performance, Walker (47) played music only during performance test. The subjects were both controlled without music and then administered music. The results of the study indicated that music does affect physical performance, concluding that activities which involve strength, endurance, and agility would be stimulated by music. The author felt that music takes the mind off the effort involved and creates a state of mind in which an individual is happy and less liable to be bored by the routine of the activity.

Chipman (6) played Sousa's "Stars and Strips Forever" while junior high students performed bent leg sit-ups in an attempt to discover the relationship between music and endurance. The author at the conclusion of his study felt that musical accompaniment, when used as a teaching technique, can be expected to increase performance in a physical education activity.

In 1911, Ayres (1) calculated the effect of music on speed in a six day bicycle race. His findings show that the participants in the race made better time when the band played. When the band was silent the times were more than when the band was playing. Ayres felt that music has a real and considerable stimulating influence on physical effort.

In an article by Troppmann (45) on, "Music as a Stimulus to Athletics" the author observed the effect of music in the dressing room at San Francisco College. The music was started as the first man entered the dressing room and stopped when the last one left. Though the problem was not scientifically investigated, it was through the author's observation that he concluded that if music is used properly it can greatly stimulate the emotions of a team. Through the use of different types of music it would be possible to achieve different moods within the team. In another article on the value of music in the dressing room, Hyat (22), also feels that music is of importance to the members of an athletic team. His views are from his observations while using music in Lee Edwards High School, Asheville, North Carolina.

Factory Production

The area of music and its use in the factory I feel is indirectly related to physical education. Ramsay and Rawson (37) found that music in the factory achieve the following:

1. Kept the worker's mind off work, and kept the standards and rate of work up.
2. Had good effects on efficiency.
3. Tended to help avoid boredom.
4. Output was increased.
5. More harmonious atmosphere in the working plant.

6. Had a calming effect on the workers.
7. Work was steadier and more consistant.

A study on the effects of music as the employee evaluated it, was done by Kerr (28). The employees found the following pertaining to music:

1. Music makes for more favorable feeling toward their associates.
2. Music had a positive effect when the workers were tired.
3. Music soothed their nerves.
4. Music helped relieve boredom.

Kerr found that music was accepted by employees in industry and that it tended to make their work less tedious. In another study by Kerr (29) on factory production and the effect of music, he found that the average output of the factory worker to be greater on days that music was played.

CHAPTER III

METHOD OF PROCEDURE

Selection of Subjects

The subjects were selected from graduate students in physical education from a neuromuscular relaxation class at Michigan State University, East Lansing, Michigan. The subjects were chosen for their background in physical education and athletics. The author felt that a background in physical education and athletics was necessary in delimiting the study. The subjects did not practice relaxation at any time during the experiment. The group was a random selection.

Instrumentation

A Newcomb phonograph with dual speakers was used to first play the music so that it could be taped by a Revere Tape Recorder. This procedure was used in order that the musical selection, "Stars and Strips Forever" by Sousa, could be slowed down until the beat was 120 beats per minute. The Newcomb phonograph is equipped with a devise that enables the speed of the recording to be changed to degrees of faster or slower than 33 1/3.

A bench, 13 inches high was used as the platform for the subjects to step on and off for their exercise.

A General Electric wall clock was used to count the length of the exercise period and the time of the pulse count.

A metronome was used along with the music in order that the subjects stay in the right cadence.

Measurement Procedure

The subjects were instructed not to engage in any vigorous or exerting activity preceeding the testing period. This was the only prerequisite to testing that the subjects had to follow. Any strenuous exercise might cause an abnormal cardiac response, the rate being in excess of the pulse before the exercise.

Each subject began the experiment in a sitting position in close proximity to the bench. The subject sat quietly until the resting pulse rate was taken for one minute. The subject then started his step test which consisted of stepping up and down on the 13 inch bench for a period of one minute and at a rate of approximately 20 steps per minute. The stepping process is performed in four counts: one, right foot is placed on bench; two, left foot is placed on the bench; three, right foot is placed on the floor; four, left foot is placed on the floor.(7) The subjects came to an erect position each time on the bench. Immediately upon cessation of exercise, the subject was seated and his pulse was counted for two minutes. The subject remained seated until his pulse

returned to normal. Again, the exercise was repeated for one minute, as before, but this time at twice the cadence as before. The stepping procedure was the same for the second test as it was for the first test. At the conclusion of one minute of exercise, pulse rate was again taken for two minutes.

John Philips Sousa's "Stars and Strips Forever" was the music used during this experiment. The music was started at the beginning of each exercise period and continued through the count of the pulse. Music was not played during the recovery period of the pulse to normal.

This selection was slowed down from 128 beats per minute to 120 meats per minute. This was done in order that there be six beats of music for each step on the first test, which consisted of 20 steps. The second test consisted of 40 steps which meant 3 beats of music for each step. The volume, base and treble were set at the same rate for each experiment.

The tests were conducted in a room 30 feet by 25 feet. The room was well lighted and had good ventilation. During the testing the subject and the author were the only ones present in the room.

Organization of Testing

The collection of data for this study was experimental. The basis for measurement was the use of the Tuttle Pulse Ratio Test.

The experimental design was the Single Group Design with each subject serving as his own control. All subjects were first tested for physical efficiency without music. They were then given two days of rest. Following the rest, they were tested for physical efficiency with music. At the conclusion of testing each subject had been tested twice, once without music and once with music, with a total of two days of rest in between testing periods.

Statistical Analysis

A statistical analysis was done to find any significant difference between the effect of music on physical efficiency and the effect of no music on physical efficiency while the subjects exercised. The data was organized using the subjects' physical efficiency percentage obtained by the testing with and without music. Each individual's score with and without music was added together to determine the mean of each group. Next, the standard deviation, the difference between means, the standard error of the mean, the standard error of difference, and correlation were computed. Finally, a t-test was computed to determine whether the difference between the means of the scores obtained with and without music was significant at the .05 level.

CHAPTER IV

ANALYSIS AND PRESENTATION OF DATA

This study was undertaken in an effort to determine differences in physical efficiency that could be attributed to the playing of selected music. To determine whether or not there was a statistically significant difference between percentages obtained from the Tuttle Pulse Ratio Test, administered with and without music, the mean standard deviation, standard error of the mean, standard error of the difference, correlation coefficient, and t-test were computed. Alpha and Beta were set at .05. Rejection of the null hypothesis for t greater than or equal to 1.74 with 17 degrees of freedom was the critical region of rejection. This means that one may be confident, at the .05 level, that in 95 times out of 100, there would be a significant difference in physical efficiency obtained with and without music, for this sample.

In analyzing the data shown in Table 1, it is seen that the mean without music was 66.11 and the mean with music was 62.11. The difference between the means was 4.00 which is not significant at the .05 level of confidence.

Correlation coefficient was computed between the physical efficiency percentages with and without music. The

TABLE 1.--The mean, standard deviation, the standard error of the mean, the standard error of the difference, difference between means, correlation, and t-test for physical efficiency percentages obtained with and without music.

	Mean	s	$s_{\bar{x}}$	s_{diff}	diff	r	t
Without Music	66.11	15.43	3.75				
				4.90	4.00	.20	.84
With Music	62.11	16.48	4.00				

correlation coefficient resulted in a score of .20. This low correlation shows little or no relationship exists between the effect of music on physical efficiency and the effect of no music on physical efficiency.

A t-score of .84 was less than 1.74, the critical region of rejection. This meant acceptance of the null hypothesis, music does not improve physical efficiency.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Eighteen graduate students in physical education were selected to participate in this experiment.

The purpose of this study was to determine whether there was a difference in physical efficiency while music was being played compared to physical efficiency with no music.

The basis for measurement was the use of the Tuttle Pulse Ratio Test. This test gives a measure of physical efficiency.

A t-test was used to determine if there was statistically significant differences between the effect of music on physical efficiency and the effect of no music on physical efficiency while the subjects exercised.

Conclusions

From the statistical analysis of the data, the following conclusions were drawn:

1. The results of this study show that music did not significantly improve physical efficiency.
2. Of the eighteen subjects tested, ten had lower efficiency percentages when music was being played.

Observation

Although the results of the experiment proved to be not significant, the author felt that the subjects seemed to work easier and more energetic while the music was played, during testing.

Recommendations

The following recommendations are made as a result of this study.

1. This study should be repeated using a larger number of subjects from many different fields.
2. The use of different kinds of music to different kinds of moods should be studied.
3. The results of this research should be verified by a similar study.
4. A study on the emotional aspects of music should be conducted.

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APPENDIX

RAW DATA ON PULSE RATES, EXERCISE STEP RATE, NUMBER OF STEPS TO A 2.5 PULSE RATIO, AND PHYSICAL DEFICIENCY

TABLE 2.--Raw data on normal pulse rate, pulse rate for 2 minutes after exercise, and the number of steps in one minute of exercise without music.

Subjects	Normal Pulse	# of Steps	2 Minute Sitting Pulse	# of Steps	2 Minute Sitting Pulse
A	66	32	135	40	165
B	76	25	133	38	175
C	80	21	155	40	195
D	80	20	189	30	212
E	60	20	150	40	200
F	72	20	149	40	174
G	64	20	143	37	169
H	64	23	160	40	192
I	62	19	129	37	155
J	60	24	127	54	256
K	64	19	143	47	243
L	64	26	144	42	193
M	80	20	189	30	212
N	68	20	146	40	197
O	60	21	131	41	194
P	56	22	128	45	184
Q	80	20	173	40	195
R	48	20	114	40	172

TABLE 3.--Raw data on the number of steps to a 2.5 pulse ratio, and physical efficiency with music.

Subjects	Normal Pulse	# of Steps	2 Minute Sitting Pulse	# of Steps	2 Minute Sitting Pulse
A	60	23	150	40	188
B	64	23	155	40	197
C	67	21	144	39	191
D	72	20	177	35	202
E	60	20	137	40	178
F	68	23	138	40	180
G	64	20	138	37	169
H	72	21	160	40	190
I	44	18	118	40	175
J	72	25	143	39	168
K	66	25	162	39	200
L	76	22	168	45	205
M	72	20	177	35	202
N	62	20	149	39	185
O	68	20	151	38	189
P	64	20	157	44	180
Q	72	21	160	40	191
R	48	20	149	35	170

TABLE 4.--Raw data on the number of steps to a 2.5 pulse ratio, and physical efficiency without music.

Subjects	# of Steps to 2.5 Pulse Ratio	Physical Efficiency
A	40	80%
B	43	86%
C	40	80%
D	25	50%
E	44	88%
F	44	88%
G	31	62%
H	32	64%
I	37	74%
J	30	60%
K	24	48%
L	31	62%
M	25	50%
N	29	58%
O	27	54%
P	27	54%
Q	44	88%
R	22	44%

TABLE 5.--Raw data on normal pulse rate, pulse rate for 2 minutes after exercise, and the number of steps in one minute of exercise with music.

Subjects	# of Steps to 2.5 Pulse Ratio	Physical Efficiency
A	49	98%
B	29	58%
C	30	60%
D	22	44%
E	26	52%
F	36	72%
G	32	64%
H	34	68%
I	21	42%
J	46	92%
K	26	52%
L	36	72%
M	22	44%
N	23	46%
O	29	58%
P	23	46%
Q	35	70%
R	40	80%