ECHOCARDIOGRAPHIC DETERMINATION OF CARDIAC STRUCTURAL RESPONSE TO ENDURANCE SWIMMING IN YOUNG CHILDREN

A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF MASTER OF ARTS

IN THE GRADUATE SCHOOL OF THE

TEXAS WOMAN'S UNIVERSITY

COLLEGE OF HEALTH PHYSICAL EDUCATION

RECREATION AND DANCE

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AUGUST 1982

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June 24 19 82

We hereby recommend that the thesis prepared under our supervision by Gary Ungar entitled Echocardiographic Determination of Cardiac Structural Response to Endurance Swimming in Young Children

be accepted as fulfilling this part of the requirements for the Degree of Master of Arts.

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CHAPTER I

INTRODUCTION

The use of ultrasound as an instrument for diagnostic work in medicine is a recent advancement (Pisko-Dubieski, Baird, & Wilson, 1975). However, the engineering aspects of ultrasound began in the 1800s. In 1833, Galton, developed an ultrasound whistle that produced vibrations as high as 25,000 cycles per second (Feigenbaum, 1976). By World War I, Langevin developed a method of producing ultrasound waves through water using a quartz crystal. By 1929, Sokolov described an ultrasound method that enabled one to detect flaws in metal. During World War II, ultrasound was used primarily by the military. Submarines could be detected underwater by the use of sonar (Pisko-Dubieski et al., 1975).

After World War II, the nonmilitary use of ultrasound was developed. Credit is given to Firestone for beginning the use of pulsed reflected ultrasound for nondestructive testing (Feigenbaum, 1976). In the late 1940s numerous investigators were using ultrasound to examine various organs of the body. The first person given credit for an examination of the heart was Keidel (Feigenbaum, 1976). In 1953, Hertz, in collaboration with Edler, obtained a commerical ultrasonoscope. Together they began to use this ultrasound device to examine the heart; this is considered to be the beginning of echocardiography (Feigenbaum, 1976).

Echocardiography was introduced to the United States by Reid who published a report in 1957 on using sonar to visualize the human heart (Wild & Reid, 1956). Reid worked with Joyner duplicating previous work on mitral stenosis. This work, published in 1963, was the first American use of pulsed ultrasound to examine the heart (Feigenbaum,1976).

Many studies have been done in echocardiography. The results of these investigations tend to find consistent data. Very few investigations have considered the effects of exercise upon the cardiac structures of preadolescents.

Purpose of the Study

The purpose of the study was to determine how intensive competitive training by swimming for children alters cardiac structures.

Statement of the Problem

The problem of the study was to investigate the influence that 12 weeks of intensive training in competitive swimming has upon the myocardial structure of male and female children. The subjects were 20 volunteers, aged 9 - 13 years, who had been swimming competitively from 1 to 8 years. The swimmers were from the Fort Worth Swimming Club. Five children of the same age group who had not been actively participating in any sport during the past year were used as a control group. The echocardiographic (echo) testing took place under the direct supervision of an echocardiographic technologist and/or a cardiologist. Each participant was screened for the presence of disease by a medical questionnaire that was completed by each respective parent or guardian. Two echocardiographic examinations (M-mode) were performed on each child; the first during the pre-season immediately after a 4-6 week period of no competition or training; the second after 12 weeks of intensive training. A conclusion was drawn concerning the effect training by swimming has upon the cardiac structure.

Rationale of the Study

The effect of training by swimming upon the structure of the heart in children remains in question. There are contradictory reports in the literature pertaining to cardiac structural changes in swimmers (Allen, Goldberg, Sahn, Schy, & Wojick, 1976; Ehsani, Hagberg, & Hickson, 1978; Lengeal & Garfas, 1979; Morganroth, Maron, Henry & Epstein, 1975). Presently there is insufficient knowledge about the effect of strenuous activities upon the cardiac structures of children. Shepard (1980) reported that it is not clear to what extent heart size is an inherited charactistic or to what degree it can be developed by sports training during childhood. The present study addresses these concerns and focuses directly upon preadolescent swimmers who have been involved in an intense training program.

Definitions and/or Explanations

For the purpose of clarification, the following terms are defined or explained:

Ao (Aortic diameter). The vertical distance between the anterior and posterior aortic walls, measured from the outermost boundary of the anterior wall and the inner boundary of the posterior wall at end diastole as indicated by the onset of the first rapid deflection of the QRS complex of the EKG (Sahn, DeMaria, Kisslo, & Weyman, 1978).

Conditioning. The Fort Worth swim team training program consisted of swimming for 12 weeks, 5-6 days per week, averaging 3,000-10,000 yards per workout. The advanced (gold) team practiced 6 days per week averaging 6-10,000 yards each day. The intermediate (silver) team practiced 5 days per week, averaging 3-4,000 yards per workout.

EF (Ejection fraction). The percentage calculated from the ratio of the stroke volume to that of the left ventricular volume (Gilbert et al., 1977).

IVSD (Interventricular sepal end diastole). A point corresponding to the beginning of the QRS of the EKG measured on the echocardiograph from the outer anterior edge of the ventricle to the inner posterior edge of the ventricle (Sahn et al., 1978).

LAD (Left atrial dimension). A measurement of the greatest vertical distance between the anterior side of the posterior aortic wall and the posterior left atrial wall during ventricular systole when the aorta is in its maximal anterior position (Sahn et al., 1978).

LVEDV (Left ventricular end-diastolic volume). The measurement calculated in milliliters as left ventricular internal dimension $(cm)^3$ (Gilbert et al., 1977).

LVESV (left ventricular end-systolic volume). The measurement of the ventricular volume calculated in milliliters during end-systole (Gilbert et al., 1977).

LVIDd (Left ventricular internal dimension at end-diastole). The measurement of the vertical distance from the endocardium of the left ventricular posterior wall to the inner posterior wall of the IVS at end diastole, beginning the QRS (Sahn et al., 1978).

LVIDs (Left ventricular internal dimension at end-systole). A measure from the peak downward motion of the septum to the endocardium in systole (Sahn et al., 1978).

LVPW (Left ventricular posterior wall thickness). The measurement from the anterior surface of the endocardial echo to the anterior surface of epicardial echo of the posterior left ventricular wall, at end diastole, beginning the QRS (Sahn et al., 1978).

Hypothesis of the Study

For this investigation the following hypothesis was tested at the .05 level of significance.

There is no significant difference in the cardiac structural dimensions of young competitive swimmers and a peer group of untrained, sedentary children, prior to or following intensive swimming conditioning.

Delimitations of the Study

The proposed study is subject to the following delimitations:

A. Twenty-five children of both sexes who are between the ages of 9 and 13 years and who have not entered adolescence.

B. Cooperation of the subjects participating in the study.

C. Representativeness of the subjects as to age, sex, and state of training.

D. Daily training schedules being representative of highly competitive swimmers.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The literature concerning echocardiography shows varying changes within the cardiac dimensions occurring after intensive training. This chapter specifically reports the studies concerning the influence of competitive swimming on cardiac dimensions. It should be noted that only two investigations have examined the influence of endurance swimming upon cardiac structures in young children (Allen et al., 1978; Lengyeal & Gyarfas, 1979). Other studies examined training effects on older individuals. The literature reviewed is presented in chronological order.

In 1975, Morganroth et al. compared the LVEDV, the left ventricular mass, and the posterobasal left ventricular wall of athletes involved in isometric exercises with those of athletes involved in isotonic exercises and a group of sedentary control subjects. The subjects consisted of 15 swimmers, 15 long distance runners, 12 wrestlers, and 15 control individuals. The experimental subjects were varsity athletes from the University of Maryland; all were actively competing at the time of the study. The ages ranged form 18 to 24 years. During resting condition, echos were taken of all subjects using an Aerotech gamma transducer and a modified Ekoline 20A ultrasound unit. A Honeywell 1856 Visicorder was utilized to obtain the recording from each subject. The athletes who participated in sports described as isometric (shot putters, wrestlers) had a greater left ventricular mass (348 g and 330 g) than did the swimmers and runners (308 g and 302 g); the control group showed the smallest mass (211 g). The swimmers and runners showed the greatest difference in LVEDV (181 ml and 160 ml) when compared with wrestlers and shot putters (110 ml and 122 ml). Again, the control subjects demonstrated the smallest volume (101 ml). Those who were described as being trained isometrically had a significantly larger posterobasal left ventricular wall (13 mm and 14 mm), whereas the athletes who were described as being isotonically trained showed normal wall thickness (equal to or below 12 mm). The investigators concluded that individuals participating in competitive sports may be diagnosed by physicians as having abnormal cardiac dimensions since they fall outside the range observed in sedentary persons.

Ehsani, Hagberg, and Hickman (1978) investigated the effects that physical conditioning had upon the cardiac structure of college students. Subjects were grouped by sport. The first group consisted of members of the Saint Louis University swimming team; there were 7 males and 1 female. Ages ranged from 17 to 19 years. None of the subjects had engaged in any physical activity for 2 to 7 months before the beginning of training. The training program consisted of 2 hour swimming workouts held 6 days per week for 9 weeks. The total distance for each session ranged from 5,000 to 7,000 yards.

Group II consisted of the cross country team of Washington University, of Saint Louis, Missouri. The team members were 6 men aged 18 to 22 years who volunteered to stop training for at least 3 weeks. The detraining occurred after 3 months of training in which the runners covered a distance of 60 to 70 miles per week. The cardiac structures that were measured included the LVEDV, left ventricular mass, Ef, stroke volume, LVPW, and LVIDd. All measurements were corrected for body surface area. An Ekoline 20A Ultrasonic unit equipped with a 2.25 megahertz 10 cm focal length transducer and interfaced with a Cambridge multichannel strip chart recorder was used for all echo measurements. The measurements were taken before, during. and after training for the swimmers; they were taken after detraining for the cross country runners. Significant changes were found as a result of swimming training; after the first week an increased LVID, LVEDV, LVED mass, and resting stroke volume index was noted. These increases were maintained throughout the conditioning period. No significant increase occurred in the LVPW until after the fifth week of training. The efection fraction showed no significant change during swimming training. The cross country team showed a significant decrease in stroke volume, LVEDd, LVEDV, estimated mass, and LVPW after 3 weeks of detraining. Ehsani et al. explained that the adaptive changes within the ventricular dimension and wall occurred more rapidly with cessation of training. In both cases, the ejection fraction was unchanged which may indicate that the left ventricular mechanical performance is not affected by training.

Allen et al., (1978) studied the effects of swimming upon the cardiac structure in 77 children. All subjects were members of the City Championship Swimming team in Tucson, Arizona. Each child practiced 6 days per week, swimming 2-6 miles under competitive training circumstances each day. The parents of each subject completed a medical questionnaire which included information concerning chronic illness; medications; number of months swimming; participation in other team sports; and if the child had temporarily ceased participation on the swim team, the date and length of time of non-participation. The coach estimated each child's ability and training level. Echocardiograms were performed with a Smith Kline 20A echo. The transducer frequencies were between 1.6 to 5.0 mhz. Echocardiographic measurements were recorded on a Honeywell 1856 UV recorder with an ECG trace used for timing purposes. The group of children tested consisted of 45 males and 32 females who ranged in age from 5 to 17 years and had a mean age of 10.8 years. The mean length of participation on a swimming team was 27 months. A randomly selected group of children the same age served as a control group. From the group of children tested, 3 had asthma, and 1 had diabetes. Each echocardiographic measurement was interpreted independently by at least two investigators.

Allen and his colleagues found that aortic root dimension, aortic intercusp seperation, right ventricular cavity, LVPW, IVSWT, and right ventricular anterior wall exceeded the 95th percentile of previously studied subjects. The mean LVIDd and the left atrial internal dimension in the swimmers were at the 50th percentile of the normal group studied. No correlation was found between the coaches' estimates of championship ability or training level and any of the echocardiographic measurements. The investigators concluded that differences existed between the echo measurements of children who participated in intensive swimming programs and those of non-athletic youngsters.

The cardiac dimensions and function of well-trained moderately trained, and untrained children were studied with echocardiography by Lengyeal and Gyarfas (1979). All children were 14 years of age. Group I consisted of 9 well-trained swimmers who had trained since age 5 years and averaged a mean of 18 hours of swimming per week. Group II consisted of 9 children who performed a mean of 8.2 hours a week of moderate exercise. The children in Group III were considered untrained and performed 3 hours of gymnastics per week. This study took place at the Hungarian Institute of Cardiology in Budapest.

All subjects were given a 12-lead ECG while at rest. A medical history was taken and a physical examination was completed. A Picker Echoview-10 was used to perform echocardiographic measurements. Measurements included the LVID, LVIDd corrected for body surface area, LV diameter percent shortening, mean circumferential fiber shortening, IVSWT, PWT, left ventricular mass, LAD, and LA corrected for body surface area.

Lengyeal and Gyarfas found that the left ventricular diameter percentage shortening, LVIDd, and percentage of circumferential fiber shortening did not show significant change. Difference in the IVSD and left ventricular end-diastolic index were significantly higher in the well-trained group than in the untrained group. The LAD, left ventricular mass, and LA were significantly greater in the well-trained group than in the moderately trained. There was a significant difference between Groups I and III in the LA index and the LA mass. There was a significant difference in the LVPW between moderately trained and untrained groups (II and III). Groups I and II demonstrated a significant decrease in resting heart rate. The LVPW and IVSD showed an increase in the well-trained group when compared with the moderately and untrained groups.

In 1980, Lamont studied the effects of training on echo dimensions in women swimmers. The subjects consisted of 11 volunteers from the Cleveland State University Women's Swim Team. Ages of the participants ranged from 18-32 years. Each subject had been swimming an average of 5 hours a week during the summer months before the study took place. A Unirad 100 series Diagnostic Sonograph coupled with an Aeortec 2.25 mhz, 13 millimeter, medium internal focus transducer was used for all echo measurements. All physiological measurements were taken before and after 13 weeks of training by swimming. The training consisted of five days per week 3 to 4 hours each day. Lamont found significant increases in LVID, LVPW, and left ventricular mass. J.R. Grima, J. Doxandabaratz, and J. Ventrua (1981) stated that the left ventricular mass was one of the most important changes that occurred with intensive endurance training.

CHAPTER III

PROCEDURES FOLLOWED IN THE DEVELOPMENT OF THE STUDY

Introduction

The purpose of this investigation was to determine the cardiac structural response to training by swimming in young, prepuberty males and females through echocardiography. The aortic diameter, interventricular septum, left atrial diameter, left ventricular dimensions, and ejection fraction were measured prior to and following 12 weeks of intensive training by swimming.

Preliminary Procedures

A review of the literature revealed that no study duplicated the design of the present study. A tentative outline was developed and revised in accordance with suggestions from the committee members. The approved outline was presented to the Provost of the Graduate School in the form of a prospectus. Permission to conduct the experiment was secured from the Human Subjects Review Committee of the Texas Woman's University.

Selection of the Subjects

The subjects of this investigation were 25 male and female volunteer children, ranging in age from 9 to 13 years. Each experimental subject (N = 20) had been swimming competitively from 3 to 8 years for the advanced (gold team) or 1 to 3 years for the silver team. All participants were members of the Amateur Athletic Union (AAU) and swam for the Fort Worth Swimming Club. Prior to the collection of any data both of the subject's parents were told the purpose of the investigation as well as all procedural steps involved. They were then asked to sign the consent form and filled out a medical questionnaire. Five children of the same age group who were not actively participating in sports acted as the control group.

The swimming team's training program consisted of swimming for 12 weeks, 5-6 days per week, averaging 4,000 - 10,000 yards per work-out. Prior to the swimming season, after a brief lay-off period of 1 month, echo recordings were performed on each individual. The echos were performed at the Doctors Professional Building near Fort Worth Osteopathic Hospital, in the office of Dr. I. Phillip Reese. The echo equipment utilized was an Irex System III, two dimensional, M-Mode, which included a strip-recorder, a monitor, oscilloscope, and a main control panel. The transducers used were a 3.5 mm unfocused and a 5.0 mm focused diameter. Several children had very small chest walls necessitating the use of the 5.0 mm transducer head. All other participants were visualized with the 3.5 mm transducer head. The subjects echos were recorded in the supine or in a slight left lateral decubitus position. Four ECG electrodes were placed on each subject in a standard configuration, and the ECG was recorded simultaneously with each echo.

The left edge of the sterum on the third, fourth, or fifth intercostal space was used as the cardiac window to penetrate cardiac structures. Aquasonic gel was applied to the transducer head to insure an air-free medium between it and the subject's skin. Most recordings were of good, clear quality, however, several children experienced breathing difficulties because of respiratory problems. This caused the subjects to breathe deeply, over filling the lung tissue resulting in blurred recordings. These subjects were coached to breathe more shallow in order to obtain a high quality tracing. The transducer was tilted toward the subject's right shoulder until the two aortic walls and left atrium were recorded. The transducer was then moved slightly inferiorly and laterally, until the ultrasound beam visualized the anterior heart wall, interventricular septum, left ventricle, anterior mitral valve, and left ventricular posterior wall. The transducer head remained at a perpendicular angle to the long axis of the heart throughout the recordings. During each examination a total of 3 recordings were taken of each individual.

Treatment of the Data

The procedures outlined below include the treatment of the data and selection of statistical design. The data were analyzed at the Computer Center of the Texas Woman's University by the Digital Equipment Corporation Model DEC 2050 Computer. Descriptive statistics were determined from the data collected. Fisher's $\underline{t}$ - test was computed to determine whether a significant difference existed between preconditioning and postconditioning echo measurements. Welch's approximation to a t test was used when the variances were unequal.

Preparation of the Final Written Report

The written report was developed by the investigator upon the completion of the statistical treatment of the data collected. The report basically consists of the purpose of the investigation, the statement of the problem, the review of literature, and the procedures followed. A conclusion to the study was determined and the implications presented. Recommendations for further studies, a bibliography, and an appendix were final sections of the report.

CHAPTER IV

PRESENTATION OF THE FINDINGS

The purpose of the present investigation was to determine if and how intensive competitive swimming training for children alters cardiac structures. In this chapter the results of the study are presented.

The data were treated descriptively and with the Fisher *t* test where appropriate. Non-parameteric techniques including Welch's approximation to a *t* test, were computed when necessary.

Description of the Subject

Table I provides descriptive statistics regarding the age, weight, and height of the 25 subjects. The female subjects ranged in age from 9 to 13 years with a mean of 11 years; the male subjects ranged in age from 9 to 13 years with a mean of 12.1 years. The mean weight of the female subjects was 37.8 kg. The male subjects had a mean weight of 41.4 kg. Height of the female subjects averaged 147.3 cm; the male subjects had a mean height of 152.9 cm. Because there was no reason to believe that sex is a major factor in the physiological variation of pre-adolescents to exercise the combined data were used for all analyses.

To determine the objectivity and reliability of the data each measurement was taken independently by a cardiovascular physician, an echocardiographic technician, and the investigator. The coefficient

Table 1

DESCRIPTIVE DATA FOR THE 25 SUBJECTS ON AGE, WEIGHT, AND HEIGHT

Variable	Range (minimum-maximum)	M	SD	SEM
Age (years)	4 (9-13)	11.4	1.38	.28
Weight (kg)	17.3 (22.2-59.5)	38.8	6.45	1.3
Height (cm)	43.2 (121.9-165.1)	149.5	9.34	1.90

of concordance was determined; the results indicated a significant difference between the independent measurements (Tau = .3025). On the basis of this finding it was determined that the echo measurements performed by Doctor Phillip Reese would be the only ones analyzed. The statistical analysis was performed using a t test comparing the following 3 groups: (a) non-swimming control group to swimmers before the swimming training resumed; (b) control subjects to trained swimmers after 12 weeks of training; and (c) trained swimmers before and after 12 weeks of training.

A comparison in echocardiographic variables between the control subjects and the swimmers prior to the resumption of training (Group I) indicated that only the LVPW and LA were significantly different (Table 2). The increase in LVPW could have been a result of the adaptation to stressful work (hypertrophy). Allen et al. (1976) found that left ventricular wall thickness and septal thickness were greater in swimmers than in control subjects. These results differed from a study done by Morganroth et al. (1975) who found that world class swimmers and runners had left ventricular wall thickness which was not significantly different from normal non-swimming subjects. Morganroth et al. indicated that swimmers and other aerobic athletes should be expected to have increased left ventricular end-diastolic volume and normal left ventricular wall thicknesses. Allen et al. (1976) studied younger subjects than those of Morganroth; however, virtually all longitudinal investigations of cardiac dimension changes have been done on adult subjects.

Table 2

ECHOCARDIOGRAPHIC VARIABLES OF INTEREST FOR THE CONTROL SUBJECTS AND FOR THE SWIMMERS BEFORE RESUMING SWIMMING

Variable	*M*		*SD*		*SEM*		*t*	*p*
	Control	Training	Control	Training				
IVSD *	.64	.70	.06	.14	.03	.03	.94	.36
LVPW	.65	.78	.07	.10	.03	.02	2.57	.02
LVID	4.04	4.12	.31	.33	.14	.07	.46	.65
LVID-s	2.64	2.83	.31	.30	.14	.06	1.24	.23
EDV	72.20	75.60	13.00	14.87	5.82	3.35	.47	.65
ESV	25.60	30.45	6.95	7.50	3.10	1.70	1.70	.20
Ef	64.60	59.35	5.86	8.22	2.62	1.84	1.34	.20
LA	2.56	2.90	.40	.28	.18	.06	2.22	.04
Aortic Root	2.16	2.32	.21	.21	.09	.09	1.55	.14

* Welch's *t* for IVSD = 1.53, *p* = .15

The large ventricular volumes reported for endurance athletes may be the result of training during a certain biological period prior to maturity, or an inherited characteristic. Results from the present study could differ from those of investigations involving older subjects. Demaria et al. (1978) suggested that there may be a gradual reduction in the trainability of the heart with the aging process.

The left atrial increase may be a result of a chronic volume overload. A study done by Zoneraich, Rhee, Zoneraich, Jordan, and Appel (1977) found that the LA was relatively larger in athletes than matched sedentary controls. No volume differences were found and the Ef was not significantly different.

The present study of only 12 weeks duration may not have been long enough to induce cardiac structural alterations in the very young, prepubescent child, or it may be that any adaptation possible had already taken place. Table 3 presents the data for the control subjects in comparison with the swimmers after they had 12 weeks of swimming. The LA and the aortic root were significantly different for the two samples. The LVID-s and ESV difference approached significance. The lack of a significant difference in LVPW over the 12 week period cannot be logically answered.

Allen et al. (1977) noted that the aortic root dimension of young swimmers was significantly larger than in sedentary controls. This could have resulted from blood volume increases that are typical in endurance training. Kjellberg, Rudhe, and Sjostrand (1949) found that blood volume was 41%-44% higher in an athletically trained group than

Table 3

THE ECHOCARDIOGRAPHIC VARIABLES OF INTEREST FOR THE CONTROL SUBJECTS AND THE SWIMMERS AFTER 12 WEEKS OF TRAINING

	M		*SD*		*SEM*		*t*	*p*
Variables	Control	Training	Control	Training	Control	Training		
IVSD *	.64	.65	.055	.12	.025	.027	.09	.93
LVPW	.65	.72	.07	.12	.03	.03	1.15	.26
LVID	4.04	4.25	.31	.35	.14	.08	1.12	.24
LVID-s	2.64	2.89	.31	.24	.14	.05	1.84	.08
EDV	72.20	81.30	13.00	14.60	5.82	3.26	1.27	.22
ESV	25.60	31.70	6.94	6.11	3.11	1.40	1.95	.06
Ef	64.60	60.36	5.85	8.41	2.62	1.88	1.06	.30
LA	2.56	2.98	.40	.36	.18	.08	2.30	.03
Aortic Root	2.16	2.46	.21	.28	.09	.06	2.25	.03

* Welch's *t* for IVSD = .14, *p* = .90

in a comparable untrained group. The increased blood volume could cause greater than normal aortic pressures resulting in increased dimensions of the aortic root.

The present study could have been affected by the fact that not all measurements were taken during ideal resting conditions. Many of the measurements were taken immediately after swimming practice. This could have resulted in a greater stroke volume, heart rate, and thus cardiac output than normal. It is not believed that this affected the dimensions measured but it could have altered true resting values. Another important factor not controlled was respiratory movements during the echo measurements. Since some of the subjects had either an allergy or asthma, respiratory efforts were difficult at times. This often causes echo pattern changes that can result in technical problems. The asthmatics involved in the study could have biased the data because of the hemodynamic changes associated with this disease. It is important to note that the changes in cardiac structures over the 12-week training period were in the direction anticipated.

Table 4 presents the data for a paired t test on swimmers, comparing them prior to the resumption of swimming and after 12-weeks of training. Only the aortic root differences were significant. The logical reason for this has been presented previously.

Chapter V presents a summary of the investigation, a conclusion to the study, and lists possible topics for further research. The bibliography and appendices follow the final chapter.

Table 4

PAIRED *t* TEST ON THE SWIMMERS PRIOR TO AND AFTER THE 12WEEKS TRAINING PROGRAM

Variables	*t*	*p*
IVSD	1.60	.13
LVPW	1.61	.12
LVID	-1.77	.09
LVIS-s	-.99	.34
EDV	-1.80	.09
ESV	-.99	.33
Ef	-.41	.70
LA	-.98	.34
Aortic Root	-3.02	.01

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER STUDIES

Summary

Many investigators have reported the effects of endurance training and cardiac dimension changes as measured by echocardiography. Relatively few investigators have considered the effects of swimming upon cardiac structures, especially those of young children. The studies that have been found in the literature used older children than the present study and the results were not consistent. The purpose of this investigation was to determine if and how intensive competitive swimming training for children alters cardiac structures.

Twenty male and female pre-pubescent children were studied before and after a 12 week swimming program. Echocardiographic measurements were obtained from each swimmer prior to resuming training after a layoff and following reconditioning. The experimental subjects were experienced competitive swimmers. Five sedentary subjects served as a control group. The data were treated statistically using a *t* test. Nonparameteric techniques including Welch's approximation to a *t* test and Kendall's coefficient of concordance were computed when appropriate.

The following findings were obtained from this investigation:

1. A comparison in echo variables between the control subjects and the swimmers prior to the resumption of training indicated that the LVPW and LA were significantly different.

2. Comparison of the echo values for the control group and the swimmers after 12 weeks of training revealed the LA and aortic root dimensions were significantly different between the two samples. The LVPW value did not retain its significance from the pretraining period.

3. A comparison between echo measurements on the swimmers before and after 12 weeks of training indicated that only the aortic root dimension changed significantly.

Based upon the statistical analysis, the hypothesis of the study that there is no significant difference in the cardiac structural dimensions of young competitive swimmers and a peer group of untrained sedentary children prior to or following intensive swimming conditioning, was rejected at the .05 level. Significant cardiac dimension differences were found prior to retraining between the swimmers and the control group in LVPW and LA. When the control group was compared to the swimmers after 12 weeks of training the LA and aortic root dimensions showed significant differences. Echo measurements showed significant changes only in the aortic root when prepubescent swimmers were compared before and after training.

Conclusion of the Study

It was concluded that certain cardiac structures and dimensions are altered by a competitive swimming program in prepubescent children.

The changes appear to be fewer and more specific than those that occur in older subjects.

Recommendations for Further Studies

After conducting the echo study involving detrained and retrained swimmers, the investigator realized that the following studies are necessary to better understand the effects of strenuous swimming activities upon very young children.

1. A study similar to the present one with a larger number of children to statistically compare male and female differences.

2. A study similar to the present one using echo to determine the long term effects of swimming upon cardiac structures in veteren children swimmers.

3. A study similar to the present one using echo to measure the effects of a longer detraining period upon the cardiac structure of young swimmers.

4. A study similar to the present one comparing preadolescent competitive swimmers to runners of the same age group.

APPENDIX

CONTROL GROUP SCORES

Subject	Aortic root	LA	IVSD	LVPW	LVID	LVID-s	EDV	ESV	E.F. %
1	2.3	2.3	.7	.75	4.5	2.9	92	31	66 %
2	2.2	2.2	.6	. 6	3.7	2.3	59	18	69 %
3	2.0	2.5	.6	. 6	4.1	2.9	74	31	58 %
4	2.4	3.2	.7	. 7	4.1	2.8	74	30	59 %
5	1.9	2.6	.6	. 6	3.8	2.3	62	18	71 %

PRETEST SCORES

Subject	Aortic root	LA	IVSD	LVPW	LVID	E.F.	EDV	ESV	LVID-s
1	2.2	3.0	.8	.8	3.5	65 %	51	18	2.3
2	2.3	3.6	.7	.8	4.2	61 %	79	31	2.9
3	2.3	3.0	.6	.7	4.2	61 %	79	31	2.9
4	2.4	3.3	.9	.8	3.9	54 %	66	30	2.8
5	2.0	2.7	.8	.8	3.9	47 %	66	35	3.0
6	2.3	2.8	.6	.6	4.1	58 %	74	31	2.9
7	2.2	2.7	.5	.6	4.0	74 %	70	18	2.3
8	2.2	3.0	.8	.5	3.8	56 %	62	27	2.7
9	2.3	3.2	.7	.8	4.0	77 %	70	16	2.2
10	2.3	2.7	.8	.9	4.1	53 %	74	35	3.0
11	2.2	3.0	.9	.8	4.5	66 %	92	31	2.9
12	2.3	2.8	.7	.8	3.8	52 %	62	30	2.8
13	2.5	3.0	1.0	.8	4.8	64 %	107	38	3.1
14	3.0	2.7	.6	.9	3.8	50 %	62	31	2.9
15	2.3	2.3	.5	.7	4.2	66 %	79	27	2.7
16	2.3	2.6	.6	.8	4.3	67 %	83	27	2.7
17	2.1	2.8	.6	.8	4.0	57 %	70	30	2.8
18	2.4	2.7	.6	.8	4.1	53 %	74	35	3.0
19	2.6	3.0	.6	.8	4.9	58 %	113	47	3.4
20	2.2	3.0	.7	.8	4.2	48 %	79	41	3.2

POST TEST SCORES

Subject	Aortic root	LA	IVSD	LVPW	LVID	LVID-s	EDV	ESV	E.F. %
1	2.2	3.0	.5	.6	4.0	2.2	70	16	77
2	2.3	3.8	.7	.8	4.7	3.0	103	35	66
3	2.3	3.5	.6	.65	4.6	2.8	97	30	69
4	2.4	2.35	.7	.7	4.4	2.9	88	31	66
5	2.2	2.6	.7	.7	4.3	3.0	83	35	57.8
6	2.25	2.85	.65	.8	4.2	2.75	79	27	65.8
7	2.0	2.5	.5	.7	4.2	2.8	79	30	62
8	2.4	3.0	.5	.8	3.2	2.7	41	27	34
9	2.5	2.5	.75	.7	3.9	2.6	66	25	62
10	2.75	3.3	.8	.85	4.25	2.8	80	30	62.5
11	2.15	3.0	.7	.8	4.25	3.15	79	38	51.8
12	2.6	2.8	.6	.7	3.9	2.5	66	26	66.6
13	2.9	3.4	.9	.95	4.2	3.0	79	35	55.7
14	3.1	2.7	.6	.8	4.2	3.0	79	35	55.7
15	2.7	2.8	.5	.75	4.2	2.95	79	31	60.7
16	2.7	3.1	.7	.5	4.5	3.0	92	38	58.7
17	2.5	3.1	.7	.7	4.2	3.0	79	35	55.7
18	2.2	3.0	.5	.5	4.3	3.0	83	35	57.8
19	2.6	3.2	.8	.8	4.8	3.2	107	41	61.6
20	2.45	3.1	.5	.5	4.6	3.1	97	38	60.8

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