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Differences In Training Programs And Time Trial Performances Of Teenage Sprint Freestyle Swimmers

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DIFFERENCES IN TRAINING PROGRAMS AND TIME TRIAL PERFORMANCES OF TEENAGE SPRINT FREESTYLE SWIMMERS

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DEDICATION

I dedicate this work to my wife, Tiffany, and to my parents, John and Brenda. Your love, support and encouragement throughout this long journey are deeply appreciated. I love you all very much.

- John

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I would like to say thank you to several people who have played an important part in my life, especially during the last four years. First, I would like to say thank you to my wife, Tiffany. Without her total support, this endeavor would have been extremely difficult. To my parents, John and Brenda, I say thank you for your constant encouragement and support. You have been there for me the entire way, and I am extremely grateful.

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ABSTRACT

The purpose of this study was to determine the effects of three different training programs on timed swims made by competitive teenage sprint freestyle swimmers of both genders during a typical five-month high school season. Coaches from five teams assigned 49 female and 38 male swimmers from age 13 through age 17 (M = 14.97 years) into one of three training programs. The programs were P1 (swim only, $n = 20$), P2 (swim plus plyometrics, $n = 59$), and P3 (swim plus plyometrics and weights, $n = 8$). Competitive swim experience ranged from novice to seven years or more (M = 5.01 years). One-way ANOVA's were conducted on post times, gain times and standardized gain times for both the 50 and 100 yard freestyles. A standardized gain time was operationalized as a swimmer's percentage gain toward achieving a USA Swimming AAAA time standard. ANCOVA tests of between-subjects effects were also performed to compare post times and gain times. These tests controlled for the effects of gender, age, total swim yards during practice, and years of swimming experience. Multiple regression analyses were used to identify predictor variables of gain and post times for the 50 and 100 yard freestyles among high school swimmers. Gender, age, total swim practice minutes and years of competitive swim experience were among the predictors. Training program P3 produced significantly higher 50 freestyle gain times than did either program P1 ($p = .028$) or P2 ($p = .001$). Similarly, program P3 also produced significantly higher 100 freestyle gain times than did either program P1 ($p = .012$) or P2 ($p = .002$). At both distances, program P1 was slightly more effective than program P2. Regression models for both freestyle events were found to significantly predict gain times. Total swim yards (50 free) and total swim minutes (100 free) were found to be non-significant predictors. A swim training program consisting, time-wise, of 80% swimming and 20% plyometrics plus weights is significantly more effective in improving sprint freestyle times of high school swimmers than a swimming only program or a program of 80% swimming and 20% plyometrics.

KEYWORDS: High School, Sprint Freestyle, Plyometrics, Weights, Training Effects

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CHAPTER I

INTRODUCTION

The 50 and 100 yard sprint freestyle events at age-group, high school and college swim meets have always been the glamour events. The same is true for international meets, such as the Olympic Games, where the events are contested in meters. Therefore, the quest for speed, and faster times, is critical.

For young age-group swimmers, 5-14 years of age, most events (including the specialties: backstroke, breaststroke, and butterfly) are relatively short in distance. The common thread for these swimmers, though, has been the freestyle stroke, which they all swim early in their careers before introduction to the other strokes. Therefore, comparison of freestyle times by young swimmers is common.

At the high school level, swimmers have begun to settle into their better competitive strokes, which may or may not include freestyle. Even so, four out of the eleven swimming events at a high school meet involve sprint freestyle at distances of 50 or 100 yards. Included are two out of the three relay events and two out of the eight individual events. There is one diving event. Point values are assigned per place, with maximum for first place and so on down the line. Relay events are scored at double the points of individual events. Collectively, 46% of the scoring in the swimming events at a high school meet involves sprint freestyle (KHSAA, 2001).

At the college level, there are additional events in the specialty strokes, so the points related to sprint freestyle drop to 30% (Lydersen, 2000). International meets such as the Olympic Games award medals instead of points, but if points were awarded, 24%

would be related to sprint freestyle (Whitten, 1996). The drop in emphasis at this level is due to one less relay event—the short relay.

The importance of sprint freestyle in the overall picture of swimming competition, particularly at the high school level, is due to the large number of swim meet events requiring this stroke and the associated high scoring value. At swimming meets, the head referee calls for quiet before the start of each race. For most events, the crowd gets reasonably quiet. However, at the start of the 50 and 100 yard or meter freestyle events, you can hear a pin drop. The start of these races is that important. Also, it is no accident that high school and college championship meets end with the 400 yard freestyle relay, where four swimmers for every team swim 100 yards freestyle. Quite often, in close meets, this last relay determines the meet's overall winner.

Success in freestyle and specialty strokes is the direct result of proper training. However, training requirements for swimming have changed dramatically over the years. The legendary Jim Thorpe was an Olympic decathlon champion in 1912. Thorpe was a natural athlete who could observe someone's performance in a sport and then go out and excel in that sport with little training. That cannot be done today without a rigorous training regime. Johnny Weissmuller, a 1928 Olympic freestyle champion and future "Tarzan", and Buster Crabbe, a 1932 Olympic freestyle champion and future "Flash Gordon", would not recognize today's swim training programs. Their winning times were reduced 17% and 22% respectively over the next 60 years (Johnson, 1993). The primary reason for this is improved training techniques (Chavoor & Davidson, 1973).

The science of swimming training has changed especially fast over the last four decades. What worked for swimmers in the 1960's and 1970's is insufficient for today's athletes. Four decades ago, swimmers would do minimal resistance training outside of the pool, whereas, today a combination of swimming, weight lifting, dry land and stretching are expected in winning programs (J. Bauerle, personal communication, February 2008). Stroke training has changed as well. Dara Torres, at age 31, qualified for the 2000 U.S.A. Olympic Team and won three individual medals, something she had not done before retiring in 1992 after that year's Olympic Games. Torres has stated that she had to learn how to swim competitive freestyle all over again in her comeback attempt after just eight years out of the water.

Many young swimmers in Kentucky begin swimming workouts as young as age five in summer country club swim leagues where all races for all strokes are just 50 meters (55 yards) in length (CKSC, 2001). Typical training consists of no more than 2500 meters (2730 yards) of swim-only practices, five days per week for about 1.5 hours (T. Cahill, personal communication, June 2000). No other training is required because of the physical maturation of the swimmers at that age. Workouts utilize the fundamentals of all four strokes. The intensity of this type of swimming regime increases with the age of the swimmer.

At the high school level, which some athletes experience while still in the 5th grade, a more advanced training program is implemented. Swimmers often have a one and a half hour swimming practice of 4500-5000 yards daily, followed by a thirty minute weight session on Mondays, Wednesdays and Fridays (T. Cahill, personal communication, October 2000). Saturday morning practices may consist of 2 hours of swimming 6000-7000 yards followed by one hour of dry land exercises. With puberty being an issue in regard to weightlifting, coaches restrict anyone who has not sufficiently gone through puberty to swim-only practices. Resistance training is used more frequently when approaching competitions (T. Cahill, personal communication, January 2000).

At the NCAA Division I level, a whole new layer of training is added. Morning practices are frequently held on Mondays, Wednesdays, and Fridays for a distance of 5000-6000 yards for the 1.5 hour workout, followed by a one hour weight lifting session. Every afternoon, a two and one-half hour swim practice of 6500-7000 yards may be conducted, followed by a thirty minute dry land and stretching program on Tuesdays and Thursdays. Saturday mornings include three hours of swimming for a maximum of 7500 yards; followed by one hour of dry land exercises (J. Bauerle, personal communication, October 1995). The quality of any workout, though, is influenced by the individual's desire, discipline and self-motivation.

During and after collegiate swimming, elite swimmers train for the U.S.A. Olympic Trials. This requires an even higher level of discipline and commitment, adding nutrition and rest to the training program. At this level, swimming becomes even more scientific in terms of training strategies, techniques and psychological factors. A sprint-specific training schedule may include two-hour swims, five days per week, for a total distance of 5500-6000 yards each day (M. Bailey, personal communication, October 1999). One-hour afternoon sessions include four sessions for weight lifting and one session for dry land exercises. On Saturdays, a 3-hour swim covering 7000 yards is often conducted.

Current Status of Kentucky High School Swimming

Competitive high school swimming in Kentucky begins on October 1st (KHSAA, 2012). Most serious high school swimmers stay in condition year round by competing for country club teams during the summer and United States Swimming (USS) teams during the winter. The High School season lasts approximately twenty weeks. Such a short season demands that work in the pool and on deck (dry land workouts) be maximized. Schools that are committed to building a quality program recognize the need to hire skilled coaches with swimming experience themselves. Easy access to training facilities is also a key to success. Less travel time, especially for the swimmers, results in more practice time. There are approximately 110 high school swim teams in Kentucky, and far fewer pools than teams. Thus, sharing pool time is the norm. Since swimming is a non-contact sport, the Kentucky High School Athletic Association (KHSAA) allows swimmers from 5th grade through 12th grade to train and compete together. The typical 20-week season begins with six weeks of moderate training, followed by eight weeks of intense training, then two more weeks of moderate training, and finally four weeks of tapering. Regular season swim meets start about November 15th, which is the end of the initial 6 weeks of training, and run through about January 30th. Qualifiers from five regional swim meets advance to the state meet. Swimmers taper for two weeks before and after the regional meets.

Physical training techniques are not uniform across the sport at the high school level. Short burst strength training is desired for sprinters, while endurance training aids distance swimmers. The former is achieved through dry land strength training and anaerobic training. The latter is achieved via aerobic training. Anaerobic training does not stress the heart and lungs as much as aerobic training. Aerobic training is termed ‘with oxygen’ and is the primary source of training. Coaches frequently interchange these two types of workouts to increase speed and endurance capacity for those swimmers who compete in the 200 yard events. These types of events are thought of as the most difficult to swim as they include endurance with a combination of speed. Current and former swimmers claim it to be a grueling controlled sprint. After finishing this event, swimmers are drained of energy. Often times “one size fits all” is the norm when it comes to workouts. This is due to only one or two coaches being available on deck to conduct and observe swimming workouts.

Most coaches at this level are former high school or college swimmers who know quite a bit about the sport. They are generally able to teach stroke mechanics and develop workouts for their teams. Relatively new coaches have less experience in motivating youthful swimmers, since they have most recently been on the receiving end of motivational talks. Motivation works differently on each swimmer, and its effectiveness is difficult to measure (Hollembeak & Amorose, 2005).

Purpose of the Study

The purpose of this study was to determine the effects of three different training programs on timed swims made by competitive teenage sprint freestyle swimmers of both sexes during a typical 5-month High School season. More particularly, the study examined the improvement of male and female swimmers exposed to three different training programs conducted at differing levels of intensity.

Significance of the Study

The significance of this study is that there is a limited amount of research that ties training regimes directly to faster swim times. Kiphuth (1942) developed supplementary land training but did not measure its effectiveness on swimmers. Morehouse and Miller (1959) demonstrated that resistance exercises worked better for swimmers if the exercises mirrored the swimming stroke itself. They did not measure this effectiveness in decrease of elapsed time, though. Castle (1993) found that training by swimming only is not the most effective way to train young swimmers. He found that resistance training improved swimmer's aerobic capacity, which he equated with improvement. He did not perform time trials to measure its effectiveness in increasing speed in the pool. Tanaka et al. (1993) utilized mixed methods to determine the usefulness of dry land and weight training. This study was designed to measure effectiveness where it counts, on the time clock, which the studies above did not attempt.

In recent years, there has been an increase in research concerning youth participation in sports, particularly in swimming. Bar-Eli et al. (2002) studied the effect of mental training on the performance of swimmers at the ages of 11 to 14 years. He found increased improvement when mental training was coupled with physical training. Bentley and Cherubini (2009) studied eighth-graders competing on high school sports teams. They reported that the development of the younger athlete depended upon not only the coach but on the senior leadership on the team as well. Garrido et al. (2010) investigated whether dry land strength training (aimed at sprint swimming) and aerobic training (aimed at distance swimming) inhibited the performance of young competitive swimmers. This training was found to have little negative effect on distance swimming and a small positive effect on sprinting. Nash and Sproule (2011) assessed how novice and expert coaches embrace new practice schemes. They found that novices mimic what they perceive as proper implementation, while expert coaches experiment and are slower to adopt new methods. Clearly, research into youth sports is fertile ground, and swimming is no exception.

Research Questions and Associated Hypotheses

The emphasis of this study was to compare several training interventions as strategies to improve sprint freestyle time trials among high school swimmers. This study was an effort to answer the following research questions and their accompanying hypotheses:

RQ #1: Are there differences in post sprint freestyle times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

Hypothesis: There will be no significant differences in post sprint freestyle times between high school swimmers trained under regimes P1, P2 or P3.

RQ #2: Are there differences in sprint freestyle gain times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

Hypothesis: There will be no significant differences in sprint freestyle gain times between high school swimmers trained under regimes P1, P2 or P3.

RQ #3: Are there differences in standardized sprint freestyle times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

Hypothesis: There will be no significant differences in standardized sprint freestyle times between high school swimmers trained under regimes P1, P2 or P3.

RQ #4: Controlling for gender, age, total swim yards during training, and years of competitive swimming, are there differences in post sprint freestyle times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

Hypothesis: Controlling for swimmer characteristics, there will be no significant differences in post sprint freestyle times between high school swimmers trained under regimes P1, P2 or P3.

RQ #5: Controlling for the gender, age, total swim yards during training, and years of competitive swimming, are there differences in sprint freestyle gain times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

Hypothesis: Controlling for swimmer characteristics, there will be no significant differences in sprint freestyle gain times between high school swimmers trained under regimes P1, P2 or P3.

RQ #6: Controlling for total swim yards during training and years of competitive swimming, are there differences in standardized sprint freestyle times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

Hypothesis: Controlling for total swim yards during training and years of competitive swimming, there will be no significant differences in standardized sprint freestyle times between high school swimmers trained under regimes P1, P2 or P3.

RQ #7: What is the relationship between baseline swim time, total swim yards, gender, and age with the freestyle gain times of high school swimmers?

Hypothesis: There is no relationship between baseline swim time, total swim yards, gender, and age with the freestyle gain times of high school swimmers.

RQ #8: What is the relationship between total swim time, years of competitive swimming, gender and age with the post sprint freestyle times of high school swimmers?

Hypothesis: There is no relationship between total swim time, years of competitive swimming, gender, and age with the post sprint freestyle times of high school swimmers.

Assumptions

1. Swimmers refrained from smoking and from drinking alcoholic beverages.
2. Swimmers were well-rested and adhered to good nutritional habits.

3. Swimmers performed at maximum effort on each time trial.

4. All swimmers received adequate coaching from their staff.

Delimitations

This study was restricted to sprint freestyle events because of their significant effect on the outcome of swim meets at all levels. Further, it is restricted to high school swimming because the influence of sprint freestyle at this level is greater than that at the collegiate and international levels.

The participants in this study were delimited to competitive swimmers because students and/or student/athletes who swim in a physical education class, for instance, would not have the same level of motivation. The training period for this study was bounded by the middle 13 weeks of the KHSAA swim season, and all training sessions and time trial swims were restricted to a six-lane 25 yard long indoor pool.

Limitations

The generalizability of the findings to swimmers who differ in levels of ability or who were trained by coaches who differ in levels of ability may not be appropriate. Applying the outcomes to swim training yardages, plyometric intensities, and weight training intensities outside the limits of this study may not be appropriate. Additionally, it may not be appropriate to apply outcomes to swimmers who were trained in pools shorter or longer than 25 yards. Finally, the relatively small sample sizes, particularly at the training regimen level, may limit the power to find statistical differences that actually exist.

Operational Definitions

Aerobic Exercise (also known as cardio) is physical exercise of relatively low intensity, depending primarily on the aerobic energy-generating process (Plowman & Smith, 2007). Aerobic literally means "living in air", and refers to the use of oxygen to adequately meet energy demands during exercise via aerobic metabolism (McArdle et al., 2006). Generally, light-to-moderate intensity activities that are sufficiently supported by aerobic metabolism can be performed for extended periods of time.

Anaerobic Exercise is exercise intense enough to trigger anaerobic metabolism. It is used by athletes in non-endurance sports to promote strength, speed and power and by body builders to build muscle mass. Muscle energy systems trained using anaerobic exercise develop differently compared to aerobic exercise, leading to greater performance in short duration, high intensity activities, which last from mere seconds up to about two minutes (Medbo et al., 1988).

Endurance Training is the act of exercising to increase stamina and endurance. The term 'endurance training' generally refers to training the aerobic system as opposed to anaerobic. The need for endurance in sports is often predicated as the need for cardiovascular and simple muscular endurance, but endurance is far more complex. Endurance can be divided into two categories including: general endurance and specific endurance. It has been shown that endurance in sport is closely tied to the execution of skill and technique. A well-conditioned athlete can be defined as the athlete who executes his or her technique consistently and effectively with the least effort (Yessis, 2008).

<u>FINA</u> stands for Federation Internationale de Natation and is the international rules-making organization for the five aquatic sport divisions, one of which is swimming. (FINA, 2012).

<u>Fins</u> are large rubber fin-type devices worn on a swimmer's feet during swim practices only.

<u>Front (Forward) Crawl</u> is a swimming stroke usually regarded as the fastest of the four front primary strokes (Maglisco, 1993). Because of this, the front crawl stroke is almost exclusively used during a freestyle swimming competition; therefore, the term "freestyle" is commonly substituted for the front crawl. This is one of two strokes that are executed along a swimmer's "long axis". The other long axis stroke is the backstroke. The front crawl stroke is different from the backstroke, the butterfly stroke, and the breaststroke in that it is not regulated by FINA. This style of swimming is often called the Australian crawl or the American crawl.

<u>High-Intensity Interval Training (HIIT)</u> is sometimes referred to as sprint interval training. It is an improved form of interval training that rotates cycles of brief "intense" anaerobic workouts with less-intense revival cycles. HIIT is a method of cardiovascular training. Customary HIIT stints vary from 5–25 minutes. Brief, concentrated sessions such as these have been found to afford enhanced physical capability (Perry et al., 2008; Laursen & Jenkins, 2002).

<u>High Intensity Training (HIT)</u> is a type of muscular exercise commercialized in the 1970s by Arthur Jones of "Nautilus" fame. This training emphasizes quality weight exercise replications to the instant of brief muscular breakdown. This training tallies the number of replications, the quantity of weight, and the length of time the subject muscle is subjected to tension (stretching), all with the purpose of increasing the level of muscle fiber engagement (Philbin, 2004.)

IM refers to the Individual Medley swimming event using all four of the competitive strokes on consecutive lengths (laps) of the race. The order must be: butterfly, backstroke, breaststroke and freestyle (front crawl). In high school swimming, the event is the 200 Yard IM, which features 50 yards in each stroke (Chinook Aquatic Club, 2012).

Institutional Review Board (IRB), also known as an independent ethics committee or ethical review board, is a committee that has been formally designated to approve, monitor, and review biomedical and behavioral research involving humans. They often conduct some form of risk-benefit analysis in an attempt to determine whether or not research should be conducted (IRB, 2012).

Interval Training is a series of repeated effort swims at a given distance with a controlled amount of rest between efforts (Counsilman, 1968).

Kick Boards are flotation devices used by swimmers during practice drills emphasizing the kick. The arms are extended forward and grip the kick board while the swimmer uses kicking propulsion only.

Paddles are colored plastic devices worn on a swimmer's hands during swim practice only.

Plyometrics are a form of training exercise intended to improve athletic performances in a variety of sports, especially those that require speed, quick muscle reaction, and powerful muscular movements (Yessis, 2009). Plyometric exercises commonly involve the rapid stretching (tension) of a particular muscle followed quickly by the rapid shortening (compression) of the same muscle.

Pull Buoys are plastic flotation devices that are shaped to fit between swimmers' legs. A pull buoy immobilizes the legs during drills that focus on arm strokes.

Resistance Training has two different meanings. One broader meaning refers to any training that uses a resistance to the force of muscular contraction (better termed strength training), and elastic or hydraulic resistance, which refers to a specific type of strength training that uses elastic or hydraulic tension to provide this resistance (Furniss, 2009).

Stations are separate areas/portions of a plyometric or weight training circuit.

Stretching can be defined as a procedure performed before a swimming workout and before the dry land exercises begin. The stretches are designed to help the athlete limber up and to improve flexibility. All muscle groups are addressed.

Swim Set is a term used to describe a series of swims prescribed by a swim coach to his/her competitive swimmers (e.g. 5 x 200 yard) (Wright, 2012).

Taper is defined as a period of reduced training typically for the purpose of improved performance (Wright, 2012).

Time Trial Performance in this study is defined as the elapsed time in 50-yard and 100-yard freestyle time trials. Each participant swims alone against the clock to eliminate the bias of slow (or fast) swimmers in adjacent lanes. Average male high school swimmers generally complete these trials in about 25 seconds and 55 seconds, respectively.

Training Parameters are components of training such as volume (e.g. distance), intensity (e.g. speed or workload), and density (e.g. training frequency) (Wright, 2012).

Training Program P1 is a program defined as 1 to 2 hours of swimming with all participants to include pre-practice stretching, followed by 0 to 0.5 hours of additional swimming, three to six days per week.

Training Program P2 is a program defined as 1 to 2 hours of swimming with all participants to include pre-practice stretching, followed by 0.5 to 1 hour of plyometrics, three to six days per week.

Training Program P3 is a program defined as 1 to 2 hours of swimming with all participants to include pre-practice stretching, followed by 0.5 to 1 hour of equal parts plyometrics and weight training, three to six days per week.

Training Sessions are also referred to as swimming practices (time periods that are typically between two and three hours in length) in which swim training is administered (Wright, 2012).

USA Swimming is the national governing body of competitive swimming in the United States. It conducts age group competitions, ranging from 10 years and under, up to 17 to 18 years of age. It is also known as USS (USA Swimming, 2012).

Warm Down refers to the loosening a swimmer performs in the warm down pool after a race. The purpose is to release lactic acid from the swimmer’s system.

Warm Up refers to the practice/loosening session a swimmer performs prior to a swimming race/meet.

Weight Training is a common type of strength training for developing the strength and size of skeletal muscles. It uses the weight force of gravity (in the form of weighted bars, dumbbells or weight stacks) to oppose the force generated by muscles through concentric or eccentric contraction. Weight training uses a variety of specialized equipment to target specific muscle groups and types of movement.

CHAPTER II

LITERATURE REVIEW

Purpose of the Study

The emphasis of this study was to compare several training interventions as strategies to improve 50 and 100 yard freestyle time trials among high school swimmers. This study was an effort to answer the following research:

RQ #1: Are there differences in post sprint freestyle times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

RQ #2: Are there differences in sprint freestyle gain times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

RQ #3: Are there differences in standardized sprint freestyle times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

RQ #4: Controlling for gender, age, total swim yards during training, and years of competitive swimming, are there differences in post sprint freestyle times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

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RQ #7: What is the relationship between baseline swim time, total swim yards, gender, and age with the freestyle gain times of high school swimmers?

RQ #8: What is the relationship between total swim time, years of competitive swimming, gender, and age with the post sprint freestyle times of high school swimmers?

Purpose of the Chapter

The current trend in swimming training combines interval training and training periodization with plyometrics and weight training. This review of the literature focuses on the impact of these training variables on peak performance in sports, especially in sprint freestyle swimming. Relevant literature will be presented in topical sections. The first five sections focus on training basics for sports in general, while the next three sections focus chiefly on swimming training. The sections are: (a) training principles to improve anaerobic and aerobic power, (b) physiological and metabolic consequences of training, (c) muscle physiology, (d) plyometric training, (e) weight training, (f) quantification of training factors that affect response and performance, (g) interval training, (h) periodization of training (taper), and (i) summary.

Introduction

The quest for speed in swimming has always been the critical goal. As a result, world records in this sport have fallen continuously over the years. One wonders what the lowest possible elapsed time for a particular event might become. Since times cannot possibly decrease to 0.00 seconds, records now are broken by hundredths of a second, instead of being broken by full seconds. Comparing old swimming techniques and training methods to newer techniques/methods is analogous to comparing Ford's Model "T" to a new Lexus.

This literature review will show that the problem of selecting an optimum training regime from among several different training regimes for high school sprint freestyle swimmers requires more research. An athlete in any sport requires some level of general training as well as some specific training in that sport. Very little research was found that compared training techniques directly with increased speed and lower elapsed times.

Training Principles to Improve Anaerobic and Aerobic Power

Overload

The "Overload" Principle refers to exercising or training at a higher intensity level than what is normally required in the performance of a particular sport. For this principle to be effective, an athlete's coach must tinker with the frequency, duration, mode, and intensity of the exercise or training technique (McArdle et al., 1996). Olympic Medalists Weissmuller (1924-28) and Crabbe (1928-32) used early training techniques called over distance (overload) training and sprint training. In other words, during training, these athletes swam distances greater than they would in competition. Next, they swam over distance using kick only, followed by over distance using arms only. They finished training by swimming a couple of all-out short sprints. The total distance would be just less than 4,000 yards per day (Counsilman, 1977). In retrospect, the distance and sprint training improved their aerobic and anaerobic strengths, respectively. There was no research concerning the adequacy of this type of training.

Specificity

In training, the "Specificity" Principle denotes changes in the athlete's physiologic and metabolic systems. "Specific exercise elicits specific adaptations, creating specific training effects" (McArdle et al., 1996, p. 394). One such training effect is VO_2max (oxygen uptake, aerobic capacity). Fifteen males completed running and swimming pre-tests in which VO_2max was measured. They then completed ten weeks of interval swim training, after which they completed running and swimming post-tests. Their aerobic capacity improved on both tests, but the increase was greater in the swimming post-test. The implication was that aerobic capacity, while improving performance, probably reaches a peak during training. Additional improvement in performance can most likely be attributed to active muscles in the specific sport rather than on respiratory or circulatory influences (McArdle, 1996). Specificity is sometimes referred to by the acronym SAID, meaning "specific adaptation to imposed demands" (Baechle & Earle, 2000).

Individual Differences

One size does not fit all when it comes to training. It is not realistic for a coach to think that all athletes will have the same level of fitness when the training season starts or that all athletes of the same gender will have the same response to a certain training load. Two college basketball forwards were monitored continuously for heart-rate during warm-ups and four fifteen-minute quarters of basketball action. One player's heart rate (cardiovascular strain) was 6.3% greater than the other player even though each performed at about the same intensity. The "Individual Differences" Principle recognizes that training responses are maximized when training programs are designed to accommodate the individual requirements and abilities of the athletes (McArdle, 1996).

Progression

In order for a training program to continue generating increased levels of performance, the intensity of the training also must increase. The "Progression" Principle will produce long-term profits if applied correctly. Methods of increasing the training intensity include increasing the number of weekly sessions, adding more exercises to the program, increasing the difficulty of the exercise, or increasing the motivational level at practice sessions (Baechle & Earle, 2000).

Reversibility

When an athlete stops exercising or training, a consequence called detraining or deconditioning occurs. One study showed that a short-term (3 weeks or less) detraining period caused an 8% decrease in VO_2max in an aerobically trained individual. A longer term (3 to 12 week) detraining period yielded an 18% decrease in VO_2max (McArdle, 1996). Even for well-trained athletes with many years of valuable exercise training, the benefits do not last very long and are “reversible.” Because of this principle, most athletes now begin a pre-conditioning program before the start of competitive training in order to recover some of the positive physiologic and metabolic functions lost to detraining (McArdle, 1996).

Physiological and Metabolic Consequences of Training

Blood Lactate, Lactic Acid

One frequently measured change in the anaerobic system of an athlete during swim sprinting and power training is the level of blood lactate. High intensity exercise increases the human body’s capacity for creating higher levels of blood lactate (McArdle, 1996). Blood lactate ($mmol \cdot L^{-1}$) is measured in at-rest conditions and after intense exercises or performances. The post-exercise concentration (accumulation) of blood lactate refers only to the balance of lactate production and elimination. It does not address the actual values of each (Fitts, 2003). In addition, blood lactate is not thought to cause the onset of fatigue. Lactic acid also accumulates during short, intense exercises such as those mentioned above. It is not believed to cause fatigue in training of any duration at less than maximum intensity (Wilmore & Costill, 2005).

Cardiovascular (Heart Rate), Pulmonary (VO_2max)

Changes in the aerobic system of an athlete during overload (aerobic) swim training include the measurement of heart rate and maximal aerobic capacity (VO_2max). Aerobic training leads to reduction of at-rest and submaximal training heart rate. The decrease in heart rate is often used as a measure of training improvement. Aerobic swim training requires an increase of breathing volume and frequency by the athlete. Hence, a well-trained swimmer with improved VO_2max will have more oxygen available to the muscles that need it during swimming performances (McArdle, 1996).

Kirwan et al. (1988) investigated the physiological responses of twelve well-trained male collegiate swimmers to ten consecutive days of intensive training. The study was conducted two weeks after the season's final championship meet. The training during this 2-week period matched the level of training during the final eight weeks of the season. During the intensive ten-day period, the daily training distance was doubled, using the front crawl stroke only, at sub-maximal effort (~95%VO_{2max}). On days 0, 5, and 11, a maximal 400 yard swim and two maximal 25 yard sprints were performed. Heart rate and blood pressure measurements were taken on these days, as well as blood samples to measure levels of various markers. As a group, performance on the 400 yard maximal swim and 25 yard sprints were not significantly changed. The elevation in the level of some of the markers, coupled with little change in performance, seemed to be a normal response to the intensified training load.

Castle (1993) studied the effects of dry land resistance training on age-group swimmers. The control group trained by swimming only, while the test group worked against resistive tubing of variable strengths. The test group performed their resistive training twice per week for a short time while the control group swam. In other words, the total volume of training was equal across the groups. The groups were matched by sex and ranged in age from 9-14 years. The results of the eight-week program showed that the test group improved their aerobic capacity by 19%, their peak post-exercise lactate concentration by 40%, and performance time to exhaustion by 24%. All test group results were relative to the control group. Castle (1993) concluded that swim training by itself is not the most effective way to train age-group swimmers, especially those in the 9-14 range.

Castle's (1993) study made an important contribution but suffered from several limitations. For example, the control and test groups should have been matched using other criteria in addition to gender. Pre-testing and post-testing were involved. However, a pre-test involving performance time to exhaustion should have been used, in addition to gender, to control for group differences existing at the beginning of the study. The percentage increase in physical capability would probably be low for an athlete already in good condition.

Aerobic, drag, and gravity costs of swimming were investigated by Montpetit et al. (1983). A large group (*n* = 68) of competitive swimmers was utilized with the group being divided among male and female, elite and junior swimmers. Oxygen consumption (VO_2) was measured in liters per minute (L/min) while the front crawl swimming stroke was performed at various speeds. Female swimmers were significantly more economical than males at any speed. Junior swimmers were generally more economical than their elite counterparts. This can be explained by drag and body weight, which is expected to be greater for the older and heavier elite swimmers, and not by greater swimming proficiency on the part of the juniors. The energy cost of transport (E_t) was measured in Joules/meter/kg. When swimming at equivalent speeds, with weight as a factor, the E_t for elite swimmers was nearly identical for each gender. Junior swimmers of each gender exhibited an E_t that was about 11% higher than their elite counterparts. To factor in drag and gravity, it was seen that at zero speed, drag is zero and gravity to be overcome is

100%. At maximal speed, it was found that drag was near a maximum while gravity to be overcome was near a minimum value. Therefore, at maximum swim speed, the energy cost with all costs factored in (J/m/kg) also is a better index of technical ability than VO_2/distance.

Toussaint and Hollander (1994) expanded on the study of Montpetit et al. (1983) concerning the energetics (energy costs) of swimming, measured in J/m/kg. They conducted a study in which performance times were measured against three different training regimes:

1. 10% increase in aerobic capacity;
2. 10% increase in anaerobic capacity; and
3. 10% increase in propelling (energy) efficiency.

All three regimes resulted in performance time reductions over short distances, but the increase in propelling efficiency produced improvements over long distances that were greater than the gains resulting from the other two training methods.

Darby and Yaekle (2000) studied the heart rate (HR) and oxygen consumption (VO_2) for comparable upright workouts in water (WA) and on land (LN). Healthy females (n = 12, 20.0 years avg.) participated. Exercises included legs only and arms plus legs in both environments. Exercise intensities were increased at 3 minute intervals. HR and VO_2 levels were higher for arms plus legs exercises and at greater exercise intensities. When water exercises were executed at HR levels equivalent to HR during LN exercises, water VO_2 levels were 2 to 6 $ml \cdot kg^{-1} \cdot min^{-1}$ higher than land $VO_{2.}$ Results showed that VO_2 was a meaningful predictor of HR. Also, HR during upright water workouts should be decreased by about 7 to 13 beats·min^{-1} for legs only WA exercises and arms plus legs WA exercises to achieve intensities similar to land workouts.

The relationship between VO_2max, lean body weight (LBW) and distance per stroke (stroke index) indicate the importance of proper stroke technique on the energy cost (VO_2max) of swimming and the resultant level of performance. The combination of stroke index and VO_2max uptake per kg of LBW correlated at a 0.97 level in a 400 yard freestyle trial (Costill et al., 1985).

Muscle Physiology

The two types of muscle fibers in the human body are the extrafusal and intrafusal fibers. The extrafusal fibers contain myofibrils, which are elements that cause muscles to contract, relax, and elongate. The intrafusal fibers, also known as muscle spindles, lie parallel to the extrafusal fibers. These muscle spindles are the primary stretch receptors in a muscle. The three forms of muscle contraction are eccentric (negative), isometric, and concentric (positive). In a multitude of sport skills, eccentric (lengthening) contractions are quickly followed by concentric (shortening) contractions (Chu, 1998).

As a result of specific overload training, different muscle fiber types respond in different manners. Long-distance swimmers have larger slow-twitch fibers than fast-twitch fibers in the same muscle as a result of aerobic overload training. Likewise, sprint freestyle swimmers have larger fast-twitch fibers than slow-twitch fibers in the same muscle due to anaerobic training (McArdle, 1996). In addition, slow-twitch muscle fibers utilize blood lactate as a source of energy during low to moderate intensity exercises (Mazzeo et al., 1986).

Training exercises for a specific sport should provide a balance of muscular strength across joints and between opposite groups of muscles. A difference in strength between the active (agonist) muscle group and the passive (antagonist) muscle group heighten the risk of injury. More advanced athletes can supplement their training by utilizing a split routine. Such a routine specifies exercises for differing muscle groups on alternating days (Baechle & Earle, 2000).

Plyometric Training

Bob Kiphuth was a Physical Education professor at Yale University and the school's swimming coach beginning in 1917. Kiphuth noted that his swimmers did not have the strength and stamina to overcome the tiring phases of swimming. He used his physical education background to develop a program to improve the strength of certain muscle groups in his swimmers. The extra sessions were not mandatory. This "supplementary land training", as it was called at the time, was very successful. Kiphuth found that his new training regime improved his swimmers' performances in less time than it would have taken in the pool. Kiphuth (1942) published a fitness manual that included photographs and descriptions of dozens of exercises. Some exercises were for general fitness, and others were of an advanced nature. All were a form of resistance training and required no special equipment, except for a medicine ball. A few exercises required a training partner for added resistance (Colwin, 1969). As a result, Kiphuth became known as the "father of land training for swimmers." Under his leadership, Yale achieved an incredible dual meet record of 528 wins against only 12 defeats. His teams won four NCAA championships. Athletes from other sports began taking part in the program. Kiphuth conducted clinics in South Africa, Australia, and many other countries.

USA Swimming has named its top performance award in honor of the former Yale and 5-time U.S. Olympic Team coach. Unfortunately, there was no written record or comparison of performances before and after using the new training technique.

Colwin (1969) was a student of the Kiphuth system. He took some of Kiphuth's exercises and further modified them for swimmers. After spending time with Kiphuth in 1952, Colwin returned to South Africa and helped to spread the Kiphuth system in that country. By the 1960's, Kiphuth's exercises were known simply as dry land exercises.

The major parts of physical conditioning for swimming are strength, endurance, and flexibility (Counsilman, 1968). A properly formulated dry land exercise regime should result in added strength and flexibility at a much faster rate than can be done by swimming alone. Some dry land exercises also may improve muscular endurance, but that is not their primary purpose. Swimming workouts are required to build cardio-respiratory endurance and muscular endurance. Counsilman (1968) developed numerous exercises involving simple stretching, resistance machines, and a weight lifting circuit. Some swimmers were found to be very flexible and in need of more weight training than flexibility training. The opposite was true of other swimmers. Consequently, Counsilman did not subscribe to a "one training regime fits all" approach.

To be considered truly plyometric, an exercise needs to include an eccentric muscle contraction followed rapidly by a concentric muscle contraction. In Sweden and Russia, this was initially referred to as the "stretch-shortening cycle." In Europe, plyometrics were thought to help an athlete shorten the "amortization" phase. That is, frequent repetitions of plyometric exercises trained sport specific muscles more quickly than simply participating in or practicing the sport. A beginner at plyometrics must be reasonably flexible. Either static (slow) or ballistic (quick) stretching exercises can be used to develop flexibility. Since plyometrics are not intended to develop aerobic capacity, a suitable recovery time between sets and repetitions is needed. Individual plyometrics include standing long jumps, standing vertical jump-and-reach, double leg hops, lateral step-ups, jump up to a box (or platform), depth jump off a step to a standing long jump, and front toss of medicine ball from feet to self. Examples of medicine ball plyometrics requiring a partner include the underhand throw, overhead throw, and backward throw (Chu, 1998).

Periodization of strength and plyometric training was examined by Bompa (1993). For junior athletes, the exercises move chronologically through anatomical adaption (~30%), development of specific strength (~15%), power development (~15%), and maintenance (~40%). Low impact plyometrics were recommended throughout, while medicine balls and light devices were specified for the power phase. For elite athletes, the anatomical adaption and maintenance phases were shorter (~15% each), with about four alternating cycles of maximum strength and power sandwiched in between. A nearly equal balance of low impact and high impact plyometrics was specified.

Gambril (1969) provided evidence to support the contention that strength was a major component in faster swimming. Just before the 1964 Olympics, U.S. swimmers began using a device called the “EXER-GENIE,” which used resistance for strength gain. Gambril credited this machine with some of the success of that year’s Olympic Team.

Tanaka et al. (1993) studied the effects of dry land resistance training on college freestyle swimmers. Two groups of 12 swimmers each were balanced based upon time trials, power values, and their specialty stroke. Both groups swam together six days a week for a 14-week program. The Swim group did nothing other than swim, while the Combo group came in three days a week for resistance training. The resistance training attempted to mimic the arm and leg motions of the various swimming strokes. Both groups had similar power gains and no change in distance per stroke. Similarly, post-tests using time trials and power values showed no measurable differences, meaning that the dry land resistance training did not improve swimming performance, even though the Combo group was able to increase the strength of their resistance training by 25-35 percent. Tanaka et al. (1993) expected dry land strength gains that would result in increased swimming power values. He attributed the lack of significant differences to the lack of specificity of training. His study is interesting in that it shows no increase in strength despite the Combo group spending extra time outside of swimming at resistance training. It is unclear what is meant by blaming specificity of training for the outcome. It could mean that resistance training that simulates the freestyle stroke did not help swimmers of the other strokes. In other words, it was too specific to help the majority of swimmers. A drawback is that readers do not know how many freestyle swimmers were in either group. It also could mean that the swim-only workout is so effective and specific that little or no strength gain can be expected from resistance training.

Plyometric training was adapted to the performance of adolescents on swimming block starts (SBS) by Bishop et al. (2009). Twenty-two adolescent swimmers were divided randomly and evenly into two training groups, habitual aquatic training (HT) and plyometric training (PT). Both groups completed the same swim training program every day for eight weeks. The PT group received two extra hours per week of plyometric training related to SBS. A baseline test from a starting block was conducted at the beginning of the 8-week period. The test measured elapsed time and velocity off the block for a distance of 5.5 meters. A post-test was conducted at the end of the 8-week training period. The PT group performed significantly better than the HT group by dropping 0.38 seconds in time and swimming (plunging) 0.26 meters per second faster off the starting blocks. This was the first study of its kind and should have a positive impact on the training of youthful swimmers.

Modeling hydrodynamic resistance on land is very difficult. Therefore, selecting proper dryland training techniques for swimming is a challenge. Weight lifting and elastic resistance do not mimic the swim stroke in water. With some training machines, the resistance used to simulate water resistance is produced by viscosity. Complicating things is the fact that water resistance increases as the speed of the swimmer increases (Zatsiorsky, 1995).

Aspenes and Karlsen (2012) reviewed 17 controlled intervention studies, most of which involved freestyle swimming. One to five repetitions of 1RM lat pull downs for three sets or sprinting while pulling a perforated bowl proved promising for improved performance and better stroke mechanics. The greatest effect on improved swim performance was for a 50 meter freestyle swim after specific dryland exercises. These exercises included 6 maximum repetitions in 3 sets involving relevant muscle groups and a routine of elastic tube assisted and resisted sprint training sets.

Weight Training

Baechle and Earle (2000) developed a useful table of sport-specific resistance training exercises. For swimming, lat pull downs, lateral raises, and lunges were recommended. They also accumulated data from multiple sources in developing guidelines for the frequency of resistance training based on the experience level of athletes. For those at the intermediate level, a training frequency of 3 to 4 sessions per week was promoted. The number of sessions per week for beginners and the more advanced were reduced or increased accordingly.

Another study (Bradshaw & Hoyle, 1993) looked at the relationship between freestyle swimming speed and upper body power. A group of seven accomplished college age swimmers used a biokinetic swim bench to increase arm and upper body power. Sprint freestyle time trials were conducted at a distance of 25 meters using arms-only and full stroke swimming techniques. A significant correlation was found between arms-only 25 meter freestyle time and swim bench power. No significant correlation was found between full stroke sprinting and swim bench power. It was concluded that the development and maintenance of upper body power should be a standard part of the dry land training program for all but the fastest (freestyle) swimmers.

A Power Rack was used by Boelk et al. (1997) to increase swimming power in female collegiate (n = 20) and USS club (n = 14) swimmers. Peak power and mean power correlated significantly with sprinting velocity in 25 yard freestyle time trials. It was concluded that the best gauge of swimming power in females is the elapsed time in the 25 yard freestyle sprint.

Halet et al. (2009) studied the relationships among free-hanging pull-ups (PU's), 1 repetition maximum (1RM) lat-pulls, and lat-pull repetitions at 80% of 1RM in NCAA Division II female swimmers. All three of these exercises are part of a typical high school swimming Dry Land (Plyometric) training program. The study evaluated the impact on arm/forearm lengths, percent body fat (%fat), body mass (BM), and lean body mass

(LBM) from each of the exercises. Swimmers (*n* = 28) were evaluated for their capacity to perform a maximum number of pull-ups and lat-pull repetitions (@ 80% of 1RM). Peak 1RM lat-pulls also were measured. Pull-ups and lat-pulls appeared to be equivalent. However, correlations between body measurements (anthropometric dimensions) and exercise performances revealed that the two exercises were not favorably related and should not be exchanged for one another.

Female age-group swimmers were studied to measure their swim performance after swim only training (Group 1), swim plus plyometric training (Group 2), and swim training combined with plyometric and weight training (Group 3) (Barber, 1998). The ages of swimmers ranged from 12 to 16 years. Time trials in 25 yard and 50 yard freestyle sprints were conducted pre- and post-training. An ANCOVA showed no significance differences for the two sprints between the groups. Similarly, t-tests showed no statistical significance for the sprints in Group 1 and Group 2. Analysis of Group 3 revealed statistical significance in both sprints.

Quantification of Training Factors That Affect Response and Performance

Mujika et al. (1995) focused on the intensity, volume, and frequency elements of a training season involving 18 elite level French swimmers. Male (*n* = 10) and female (*n* = 8) swimmers participated in a 44-week training season. The average swimmer was 20.5 years of age with 12 years of competitive experience. Half of the swimmers specialized in 100 meter events, while the other half swam 200 meter events. Variations between the swimmers who improved their personal best times from the prior year (GIR, *n* = 8) and those who did not (GNI, *n* = 10) were examined. There were five levels of training intensity, with the greatest volume of swimming occurring at the lowest level of intensity, and so on. The mean intensity of the training season (MITS) was calculated in arbitrary standardized units for each swimmer (range = 1.42 to 1.64). Three performance measures were used: the previous year's record, the initial performance in the training season, and the record performance in the training season. There were three competitions during the training season accompanied by varying periods of taper. The seasonal averages were: 7 practices per week, 3560 meters (3890 yards) per practice, and 30 minutes of dry land exercises per week.

Mujika et al. (1995) found that the training intensity (MITS) was connected to the increase in performance for the swimmers during the full training season. The same was not found to be true for training volume and frequency. However, a reduction in training volume during the first 3-week taper was positively related to improvement in performance. Finally, there was a negative relationship between the initial performance level of the season and the improvement over the full training season. For example, one swimmer whose initial season performance was about 88% of his/her personal best for the prior year improved over the initial performance by about 10%. Another swimmer's initial performance was about 96% of his/her prior year's personal record, but she only improved on the initial performance by about 4% at the end of a full season of training. Therefore, a factor such as excessive detraining after the previous season could put success at risk despite a swimmer's positive adjustment to training.

The links between sprinting (elapsed time for 25 yards) and peak power (measured by Biokinetic swim bench performance) indicated a linear relationship between velocity (m/sec) and swimming power (watts) (Costill et al., 1983). However, previous tests involved swimmers with widely varying maximum swim performances. At the 1982 USS Long Course Nationals, elite level male and female swimmers were tested at 25 yards in the pool with the Biokinetic swim bench. Parallel dryland power measurements also were made. Swim bench power associated with dryland power yielded a significant correlation with sprint velocity ($r = 0.62$). This was similar to the correlation at velocities in the 1.7 to 1.9 m/sec range, but not at the elite velocities of about 2.1 m/sec ($r = 0.25$). These results provide strong evidence that the resources that lead to success in sprint freestyle swimming are built on more than strength.

A formula for defining athletic (swimming) progress in units of training and fatigue was proposed by Banister et al. (1975). The formula attempted to equate swimming distances at various levels of intensity with weight training repetitions to arrive at a training impulse (TRIMP). The study involved one elite level swimmer. Tabular data indicate that nine actual swim times in the 100m freestyle compare favorably with modeled swim times, though no statistical tests were included in the publication. The implication is that training volumes and intensities can be adjusted during the training season to achieve a particular improved swim time.

A similar model for predicting improvement of performance was developed by Mujika et al. (1996). Training time was plotted on the abscissa, and performance time was plotted on the ordinate. The variables were the positive influence (PI) of fitness and the negative influence (NI) of fatigue. A 44-week season included three (3) tapers of three weeks, 4 weeks, and 6 weeks, respectively. Improvement occurred during the first two tapers due to a reduction in negative influences (fatigue). The positive influence of fitness was not compromised by the reduction in training during the tapers. Competition times improved about 3% during the first 2 tapers. It was hypothesized that the final taper was too long (6 weeks) and that the model was a valuable tool.

The work performed by Banister (1975) and Mujika (1996) was expanded by Borresen and Lambert (2008). They produced a model for quantifying a training load using a subjective measure (rating of perceived exertion, RPE) and an objective measure (heart rate, HR). Their training impulse (TRIMP) used the objective measure of heart rate as opposed to the arbitrary measure of training units (TU's) of Banister. The RPE rating used by Borresen and Lambert (2008) was on a 0-10 scale. The Borg RPE scale, used by others, ranges from 6-19. This model yields a reasonably valid quantification of training load unless a disproportionate amount of time is spent exercising at low or high intensity.

Interval Training

At the start of the 1970's, high yardage swimming was the main vehicle for improving endurance. Over distance training was used, along with sprint training, but a new technique was emerging. Chavoor and Davidson (1973) discovered what is now known as "interval training." He was an advocate of over distance training but felt that it was insufficient by itself. By requiring swimmers to complete strenuous "sets" and gradually reducing the rest period between sets, he "invented" what is known today as interval training. Researchers discovered that this exertion caused the buildup of glycogen and glycolytic enzymes in the swimmer's muscles (Holloszy & Booth, 1976). These enzymes enabled the swimmer to continue over long periods with little or no oxygen to the muscles. This was a very important discovery that opened up new areas of research opportunity. After this discovery, researchers focused on training techniques that built up aerobic capacity and reduced lactic acid in the blood stream.

A survey of 24 coaches and 185 age-group/open-class USS swimmers regarding prearranged training versus season-best efforts was conducted by Stewart and Hopkins (2000). The study was broken down into two areas, one for those focusing on sprints (50/100 meters) and a second for those focusing on middle distance (200/400 meters) events. The four phases of a typical season were build-up, focus on stroke, taper, and post-competition.

Stewart and Hopkins (2000) discovered the following relative to training:

1. Coaches specified higher yardage and more repetitions of lower intensity to middle-distance swimmers than to sprinters;
2. When nearing a competition, the intensity of repetition and duration of rest intervals lengthened, while session distances and repetition distances decreased;
3. The weekly yardage swam at an easy or moderate pace stayed at about 60% of the total weekly yardage all through the season; and
4. Interval training gradually reduced from 40% of the total yardage during the build-up, to about 30% of total yardage at the end of the taper.

The only significant positive correlation between performance and training was demonstrated by an increase in weekly yardage and shorter rest periods in middle-distance swimmers.

Exercise intervals for a swimmer performing sprint workouts should be based on the swimmer's best times. For 25 yards or 50 yards, add 1. 5 to 5 seconds to arrive at the exercise interval. For 100 yards, take the best 100 yard increment from the swimmer's best 400 yard swim and subtract 1 to 4 seconds. Recommended rest (relief) intervals vary according to the energy system. For short-term anaerobic training, such as sprinting sets, the relief interval is suggested to be 2:1 or 3:1 (rest: exercise). Long-term aerobic training for endurance swimmers is usually recommended to be in the ratio of 1:1 or 1.5:1. The rest period is usually passive as opposed to active (McArdle, 1996).

Periodization of Training (Taper)

A 25-week full season study of training volume was conducted by Costill et al. (1991). It included 24 male collegiate swimmers divided evenly by skill and experience into a LONG training group and a SHORT training group. The standard swimming program lasted 1.5 hours per day, five days per week. The SHORT training group trained under the standard program for all 25 weeks. The LONG training group swam twice per day, doubling the time and yardage of the SHORT training group during weeks 5 through 11. The LONG training group matched the SHORT training group during all other weeks of the study. Results showed that the swimmers made notable improvements in swimming power, endurance, and performance throughout the 25-week program. However, there were no significant differences in these measures between the groups. During the 6-week high volume training period, the sprinting velocity of the LONG group declined as compared to the SHORT group. Both groups showed little improvement in swimming endurance and power after the first eight weeks of training. Major competitions at weeks 13 and 25 were preceded by 2-3 weeks of reduced training (taper). Best seasonal performances were generally achieved by all swimmers after taper. Time trial comparisons in 50-yard and 100-yard freestyle sprints during weeks 4 and 11 revealed little difference between the groups. Both groups were about 1.0 percent slower at 100 yards. The LONG group was about 1.5 percent slower at 50 yards compared to less than 0.5 percent faster for the SHORT group.

Garrido et al. (2010) studied the effects of dry land strength training in combination with aerobic swimming training on young competitive swimmers. Twenty-three young swimmers were divided randomly (and approximately evenly) in number and gender and placed into a control group or an experimental group. During the initial eight weeks, both groups participated in an aerobic swimming training program six times per week for 1.5 hours. The experimental group participated in a strength training program two times per week. A 6-week training session, identical to the 8-week session followed, except that the experimental group ceased the strength training (i.e., went through de-training.) Time trials in the 25m and 50m sprint freestyle were conducted prior to the 8-week session, between the 8-week and 6-week sessions, and at the end of the 6-week session. The outcome indicated that sprint performance improved for both groups, sprint performance was somewhat enhanced by strength training, and sprint performance still improved after the de-training period.

Bompa (1993) constructed a Power-Speed-Endurance triangle to illustrate the sport-specific combinations between the dominant bi-motor skills. For sprint swimming, he emphasized starting power, acceleration power, and short term muscular endurance.

Summary

Studies involving training center around swim only training, swim plus plyometric training, and swim coupled with plyometric and weight training. Some researchers look at all three regimes, while others focus on the first two. All generally focus on sprint freestyle swimming. Nearly all studies involved collegiate or elite level swimmers. Such studies were generally conducted in an academic environment.

Only the research performed by Barber (1998) and Garrido et al. (2010) examined young (ages 12 to 16) swimmers. In the former, some gain in performance was seen in a training group utilizing swimming in combination with plyometric and weight training. In the latter, sprint performance was enhanced by strength training. It is encouraging that swimming performance in young high school age swimmers has been shown in the literature to likely be improved by other training interventions.

A major obstacle in researching high school swimming is the reliable quantification of training load. Measuring heart rates, VO_2max, and blood lactate are beyond the scope of what a high school coach can perform. Likewise, teaching young swimmers about RPE is not likely to be successful. Therefore, this study focuses solely on the effect of three different training regimes on the freestyle sprint time of high school swimmers. The chapter that follows describes the methods of this study.

CHAPTER III

METHODOLOGY

To reorient the reader, the purpose of this study was to compare three training regimens as strategies to improve 50 and 100 yard freestyle time trials among high school swimmers. Specifically, this study addresses the following research questions:

RQ #1: Are there differences in post sprint freestyle times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

RQ #2: Are there differences in sprint freestyle gain times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

RQ #3: Are there differences in standardized sprint freestyle times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

RQ #4: Controlling for gender, age, total yards swam during training, and years of competitive swimming, are there differences in post sprint freestyle times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

RQ #5: Controlling for the gender, age, total yards swam during training, and years of competitive swimming, are there differences in sprint freestyle gain times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

RQ #6: Controlling for total yards swam during training and years of competitive swimming, are there differences in standardized sprint freestyle times between high school swimmers trained with a swim only training program (P1), a swim + plyometrics training program (P2), or a swim + plyometrics + weight training program (P3)?

RQ #7: What is the relationship between baseline swim time, total yards swam, gender, and age with the freestyle gain times of high school swimmers?

RQ #8: What is the relationship between total swim time, years of competitive swimming, gender and age with the post sprint freestyle times of high school swimmers?

The issues examined in this chapter include: a) selection of study subjects, b) design of the study, c) methods for collecting data, and d) treatment of data.

Sample Selection

Four Kentucky high school swim coaches, along with the Principal Investigator (also a high school swim coach) agreed to participate in the study. Coaches were contacted on or about September 15, 2012, with the study beginning on November 1, 2012. The total number of participants from the five (5) swim teams numbered eighty-seven (87), including forty-eight (48) female and thirty-nine (39) male swimmers.

Approximately 75% of eligible swimmers chose to participate. All participants were between the ages of 13 and 17, inclusively, at some point during the 13-week intensive training portion of the study.

Study Approval

The study was approved via a letter of support from each school district and by Eastern Kentucky University's Institutional Review Board (IRB). A script was read to all potential participants, and an information sheet was provided to all. A "Parent/Guardian Permission Form for Minor's Participation in a Research Project" was signed by all parties. This "informed consent" document was obtained from each subject and from each subject's parent or guardian, as required by IRB policy. Per KHSAA and school district policies, each participant provided a valid physical exam document, certifying their fitness to participate in high school swimming for the current season. Before volunteering, each subject was informed of the purposes and procedures used in the study, as well as any potential risks. This was done by individual school coaches reading from identical scripts approved by the IRB.

Stages of the Study

The span of study included the following stages:

1. Three to four week pre-conditioning stage.
2. One-day pre-training time trial stage with questionnaire.
3. Thirteen-week intensive training stage with three different training interventions.
4. One-day post-training time trial stage.

Swimmers not participating in the study were not administered the questionnaire nor were they subject to time trial and other forms of data collection. They were, however, coached and treated in the same manner as the study participants. The study was conducted in a transparent manner.

Due to limitations in pool time, the number of practices and total hours trained per week varied from team to team. Coaches varied swim workouts from day to day, but all swimmers on a particular team swam the same workout on a given day. The same was true for all members of plyometric and weight training groups.

Pre-Conditioning Stage Protocol

During this stage, coaches assigned swimmers to one of the three training groups. This stage lasted for a period of three to four weeks and focused on technique and conditioning. A coach with a swimming + plyometrics training group introduced plyometrics during this stage. Weight training in the appropriate group was minimal at this time.

One-Day Pre-Training and Questionnaire Stage

A six-question survey was administered to each swimmer. The survey used a 5-point Likert Scale. Only one of the questions was used in the analysis. It was referred to as Survey 1, Question 2 (SurQ2) during data collection and is as follows:

2. How much competitive swimming experience do you have?

   (Practice with a team and compete for the team in Swim Meets.)

At the end of the pre-conditioning stage and after the survey administration, the pre-training stage took place over one day. During this stage, the coaching staff conducted a time trial in sprint freestyle at distances of 50 yards and 100 yards, respectively. After 10-15 minutes of stretching, swimmers entered the water and began with a warm-up swim usually consisting of 500 yards. The idea was to swim easy at first and slowly build up speed as the muscles warmed up. Mixing up all four strokes; butterfly, backstroke, breaststroke and freestyle; ensured that a swimmer's total body was ready to compete. The next portion of the warm-up was for the swimmers to grab a kick board and kick for 300 yards while mixing up the kicks for all four strokes. Stroke drill on the specific stroke that was being tested (freestyle) was the next portion of the warm-up. A set of four by fifty yard freestyle swims working on hip roll, extending stroke length, high elbows, and breathing pattern were all part of this segment. Burn-outs, which are defined as extra fast kicking and arm movements, were performed off each end wall for a distance of 10 to 15 yards. Fast flip turns were practiced approximately two to three times depending on a swimmer's needs. Lastly, one to two dives off the starting block were performed while working on quick reactions. Swimmers were then deemed warmed up and ready for the 50 yard freestyle time trial.

The time trial itself was conducted with the swimmer competing alone in the pool against the clock. This was done to avoid the bias of a swimmer competing in a lane adjacent to slow (or fast) swimmers.

After the first time trial, the swimmers loosened up in a warm-down lane in the pool for about 15-20 minutes, or until lactic acid was depleted from their muscles. The 100-yard freestyle time trial was conducted after 20 to 30 minutes of appropriate rest. Swimmers completed each time trial in the same order and under the same conditions. The Principal Investigator or his/her assistant coach recorded each participant's time in the 50 and 100 yard freestyle pre-time trials. These served as each swimmer's baseline for improvement.

Intensive Training Stage

This stage lasted for a period of thirteen (13) weeks. At this time, all three training programs were being fully implemented. All participants for a particular team had the same swimming component in all three training programs. In addition, one week of taper was built into each team's program at the end of this training period. The three training programs are defined below.

Training Program P1 - Swim Only - This program was comprised of one to two hours of swimming by all participants and included pre-practice stretching, followed by zero to one-half hours of additional swimming, three to six days per week.

Training Program P2 - Swim + Plyometrics - This program entailed one to two hours of swimming by all participants and included pre-practice stretching, followed by one-half to one hour of plyometrics, three to six days per week.

Training Program P3 - Swim + Plyometrics + Weights – This program was comprised of 1 to 2 hours of swimming by all participants and included pre-practice stretching, followed by one-half to 1 hour of equal parts plyometrics and weight training, three to six days per week.

Swim Workout

Each head coach selected a daily workout that varied in yardage, pace, and resting intervals. In this study, sets varied from day to day. Workouts usually included a warm-up set that included swimming with a specific amount of yardage, a kick with a specific amount of yardage, and a drill with a specific amount of yardage. After the warm-up, a pre-main set continued to get the body warmed up and also worked on conditioning techniques. The main-set was the most demanding portion of the workout, using the most amounts of energy and time. Yardage varied in this area, and special instructions were given to swimmers with a break in time. Usually swimmers had a water and restroom break at this time as well. After the main set, a specialty set was conducted to focus on key stroke drills, dives, or streamlines off end walls with explosive push-offs. Finally a warm-down was prescribed with swimmers going easy for approximately 300 to 400 yards to flush out lactic acid and prevent muscle soreness.

Sample Swim Workout

1200 yds.	Swim 600 yds. (swimmer's choice)
	300 IM Kick (75 yds. kick only ea. stroke)
	300 IM Drill (75 yds. ea. stroke)
1200 yds.	Swim 6x200 @ 3:30 - IM, FREE, BACK
	(200 yds. IM, 200 yds. Free, 200 yds. Back)
	(Send off every 3:30, then repeat)
300 yds.	Drill 300 BACK
	(300 yards backstroke)
600 yds.	Swim 6x100 BACK @1:45
	(100 yards backstroke; 6 times; send off every 1:45)
300 yds.	Kick with medicine ball in front
	(freestyle kick, hand-held medicine ball)

600 yds. Swim FLY Set (4x25 @30 sec, 1x100 on 2:00) 3x's

(25 yds. fly, 4 times at 30 sec. send offs; then 100 fly)

Start over at 4:00. Do 3 times.

300 yds. Swim Down (swimmer's choice)

4500 yds. = Total for Practice

Plyometrics

Plyometrics are exercises that attempt to simulate the streamline motion of the swimming stroke. Typically 3 sets of 8 repetitions for all exercises were assigned. Plyometrics (dry land exercises) are important to the swimmer as they build strength in the core area. If a swimmer has a strong core, they will not tire as quickly as those who do not.

Upon completion of the swimming workout, swimmers designated for plyometrics changed into their dry land outfits to include: shorts, t-shirt, socks and tennis shoes. The reason for this request was to prevent injury by using proper footwear that supports the ankles and limits shock to the joints along with providing complete body movements without restrictive clothing. As the team assembled, a shorter version of stretching occurred for approximately 5-10 minutes. Depending on the coach, a variety of activities were used.

Below is a list of common plyometric exercises:

1. Medicine ball trunk twist, chest press, chest throws, overhead throws, and two-handed basket toss, all with partner.
2. Medicine ball jump back and forth over ball.

3. Stadium jumps from upright position on bleacher to squat position on floor.
4. Laps around indoor track.
5. High knees skipping.
6. Forward leg lunges, alternating.
7. Stretch cords.
8. Stretch cords, simulating swimming strokes.
9. Partner leg throws.
10. Crunches with legs up.
11. Pushups.
12. Flutter kicks on back.

Weight (Resistance) Training

Weight training is a training technique that utilizes free weights (barbells) and all the machines typically found at a fitness center. All muscle groups are addressed. Only swimmers who reached puberty and had parental/guardian consent lifted weights. The reason for lifting weights was to strengthen core muscle areas and provide muscular endurance to finish the swim race. Not every team had the ability to conduct weight workouts. Typically, swimmers were asked to do 3 sets of each exercise for eight continuous repetitions. Swimmers worked out in pairs so that proper technique could be critiqued and spotting could occur. Spotting another swimmer while they lifted weights ensured the lifter that the weight would not fall and injure him or her in the event they became fatigued. Novice weight lifters needed extra coaching and started off with extremely light weights. As in any sport or exercise, a conditioning period was needed for several weeks to orient the muscle groups to this new workout. In consultation with the team strength coach or head coach, a test day or max-out day was conducted. This set a baseline for improvement over the season.

Below is an extensive list of weight lifting exercises that swimmers used for strength gain:

Bench press	Calf raises	Fly’s
Arm curls	Leg curls	Triceps extensions
Lats	Leg presses	Pushups
Military press	Sit-ups	

Post-Training Time Trial Protocol

At the end of the 13-week intensive training stage, the coaching staff again conducted a time trial in sprint freestyle at distances of 50 yards and 100 yards, respectively, for each swimmer. The protocol was identical to that of the pre-training time trials described previously. Once again the Principal Investigator or his/her assistant coach recorded each participant’s time in the 50 and 100 yard freestyle post time trials. These were used to measure each swimmer’s improvement.

Data Collection Procedures

Age and Sex of Participants

This information was collected simultaneously with consent forms.

Pre-Conditioning Training Data

Most subjects participated in swim only conditioning programs. No data were collected for this portion of the study.

Questionnaires

These were completed by each swimmer and collected by the coaches before warm-ups on the day of the pre-training time trials.

Pre-Training Time Trials Data

Elapsed times for 50-yard and 100-yard time trials for every swimmer were measured with hand-held stop watches, accurate to the nearest 0.01 seconds.

13-Week Intensive Training Data

For Training Program P1 (Swim Only), swimming yardage and time (minutes) in the pool were recorded every day for every swimmer by the coaches. For Training Program P2 (Swim+Plyometrics), swimming yardage, time in the pool, and time in plyometrics were recorded every day for every swimmer by the coaches. For Training Program P3 (Swim+Plyometrics+Weights), swimming yardage, time in the pool, and time in plyometrics/weights were recorded every day for every swimmer by the coaches. Absences from practices or lack of participation due to injury were recorded daily for each swimmer by the coaches.

Post-Training Time Trials Data

Elapsed times for 50-yard and 100-yard time trials for every swimmer were once again measured with hand-held stop watches, accurate to the nearest 0.01 seconds. These were collected by the Principal Investigator or coaches.

Variables

The study included three dependent variables. These were the post swim times (time trial 2), gain times (between baseline and post), and standardized times based on gender and age as embedded in AAAA benchmark times. The independent variables were the three training programs (interventions). Covariates included gender, age, total swim yards, total swim minutes, and years of competitive swim experiences. Predictor variables included baseline swim times, gender, age, years of competitive experience, total swim yards and total swim minutes.

Data Analyses

This quantitative study utilized causal comparative and correlational research designs. One-way ANOVAs were used for research questions one through three and assessed the effect of the three training programs on swimming performance in the 50 and 100 yard freestyle events. Swimming performance was measured by post times in the 50 and 100 freestyle, gains from the pre-time to the post swim time in the 50 and 100 yard freestyles, and standardized swim times in the 50 and 100 yard freestyle.

To address questions four through six, ANCOVAs were utilized. These six ANCOVAs focused on the same dependent variables measured in the first three research questions. The dependent variables included post, gain and standardized swim times. Predictor variables included age, gender, total swim yards, years of competitive experience, total swim minutes, and baseline (initial time trial) swim times.

ANCOVA's were performed to test for the significance of the independent variables on the same dependent variables. As noted above, covariates included gender, age, total swim yards, total swim minutes, and years of competitive swim experiences. Since standardized scores already account for gender and age differences, they were not used as covariates when standardized scores were the dependent variable.

Finally, simple linear regressions were run to answer research questions seven and eight. The dependent or criterion variables were post swim time and gains in swim time for the 50 and 100 yard freestyles. Predictor variables included age, gender, total swim yards, years of competitive experience, total swim minutes, and baseline swim times.

Assumptions required for all tests were met. Significance of all statistical tests was interpreted at the 0.05 alpha levels.

Participants

A total of eighty-seven subjects participated in this thirteen-week study. All participants (49 female, 38 male) were high school swimmers. The subjects represented five different schools ranging from grades seven through twelve inclusively (ages 13 through 17). The level of prior competitive experience ranged from none to 7 years or more.

Table 3.1 indicates the number of participants from each team and grand total, while Table 3.2 reports the total number of subjects involved within the three different training programs. The number of subjects participating in the different training programs at each individual school is displayed in Table 3.3.

Table 3.1
Team Participants

Team	N	Percent
Team #1	35	40.2
Team #2	5	5.7
Team #3	23	26.4
Team #4	13	14.9
Team #5	11	12.6
Total	87	100.0

Table 3.2
Training Program Participants

Program	N	Percent
Swim Only (P1)	20	23.0
Swim, Dry Land (P2)	59	67.8
Swim, Dry Land, Wts. (P3)	8	9.2
Total	87	100.0

Table 3.3
Training Program: Team Crosstabulation

	Team					
Program	#1	#2	#3	#4	#5	Total
P1	11	1	4	0	4	20
P2	21	2	18	13	5	59
P3	3	2	1	0	2	8
Total	35	5	23	13	11	87

Table 3.4 presents the gender distribution among the 3 training programs. The age distribution within the training programs follows in Table 3.5. The gender and age variables were important since each age group of each gender had a unique national swimming time standard for comparison purposes. In this study, the time standard chosen was the “AAAA” level as published by United States Swimming (USS).

Table 3.4
Training Program: Gender Crosstabulation

Program	Female	Male	Total
P1	10	10	20
P2	37	22	59
P3	2	6	8
Total	49	38	87

Table 3.5
Training Program: Age Crosstabulation

Program	13	14	Age 15	16	17	Total
P1	3	5	7	4	1	20
P2	9	10	17	18	5	59
P3	0	3	1	3	1	8
Total	12	18	25	25	7	87

The level of each participant's competitive swimming experience was determined via a questionnaire (Survey 1, Question 2). The experience level in each training program is presented in Table 3.6. Note that there is a difference in the sample means of competitive experience by actual years (M=5.01) and by data entry code (M=3.97).

Table 3.6:
Training Program:
Years Competitive Swimming Experience Crosstabulation

Years (Data Codes) Program	0 (1)	1 (2)	3 (3)	5 (4)	≥7 (5)	Total
P1	0	1	3	6	10	20
P2	5	4	11	12	27	59
P3	2	0	0	1	5	8
Total	7	5	14	19	42	87

The next chapter presents the findings of this study. The findings are organized in the order of the eight research questions assessed in this study.

CHAPTER IV

RESULTS

Introduction

This study compares the effects of swim only training (P1), swim plus dry land training (P2) and swim plus dry land and weight training (P3) on swimming time improvement for high school swimmers. Baseline and post time trials were completed by all swimmers in the 50 and 100 yard freestyles at the beginning and end of a 13-week training period. Baseline, post, gain (difference between baseline and post times) and standardized times were analyzed using IBM SPSS 21 statistical software. An alpha (α) level of .05 was used to interpret statistical significance.

First in this chapter, descriptions of the participants and the training means are illustrated in order to provide a picture of the variety in the swimmers and their training programs. Next, results are presented from ANOVA's and ANCOVA's comparing the mean differences in swim times between the three training programs assessed in this study, with the latter analyses controlling for swimmer characteristics. The dependent variables are post swim time, gain swim time, and standardized times (considering gender and age in the AAAA benchmark). All analyses were conducted on freestyle swims at distances of 50 and 100 yards. Finally, the results of simple linear regressions predicting gain times and post swim times for the 50 and 100 yard freestyles are presented.

Description of Participants

High school swimmers (49 female, 38 male) ranging in age from 13 to 17 years participated in this thirteen-week study. Their level of prior competitive swimming experience ranged from none to 7 years or more.

Table 3.2 on page 55 indicates the populations of the three training programs while Table 4.1 includes the means of some swimmer characteristics. Data for all 87 participants was collected over the entire duration of the 13-week training period.

Table 4.1
Sample Means of Swimmer Characteristics

Description	Mean (*n* = 87)	Values
Gender	1.44	F = 1, M = 2
Age	14.97 yrs.	13 – 17 yrs.
Experience	5.01 yrs.[a]	0 – 7+ yrs.

[a] Questionnaire code mean = 3.97

Training Means

Means for Total Practice Days Attended, Total Swim Yards, Total Swim Time (minutes), Total Plyometric Time (minutes) and Total Weight Time (minutes) for each training program are outlined in Table 4.2. The data included in Table 4.3 were not used elsewhere in any analysis but provide a picture of the daily/weekly swim yardage and weekly time spent in the various training programs. Yards per day were based on practice days attended, while all weekly averages were based on a 13-week training period. Compared to P1 subjects, participants in P2 spent about one-half hour less per week in the pool but spent that one-half hour plus about another full hour on plyometric training each week. Participants in P3 spent about 2 hours more per week in the pool than did P1 subjects. In addition, they spent 2 hours per week split between plyometric and weight training, while P1 subjects performed neither.

Table 4.2
Training Means: Total Practice Days, Total Swim Yards, Total Swim Time, Total Plyometric Time and Total Weight Time

Training Program	Total Practice Days Attended	Total Swim Yards	Total Swim Time (minutes)	Total Plyometric Time (minutes)	Total Weight Time (minutes)
P1 (*n* = 20)	45.70	215,940	4989	0	0
P2 (*n* = 59)	46.44	182,663	4514	1149	0
P3 (*n* = 8)	60.88	285,027	6791	780	769
Total (*n* = 87)	47.60	199,726	4832	851	71

Table 4.3
Daily and Weekly Training Averages by Program

Program	Swim yds/day	Swim yds/wk	Swim min/wk	Plyometric min/wk	Weights min/wk	Total min/wk	Total hr/wk
P1	4725	16,611	383.8	0	0	383.8	6.40
P2	3933	14,051	347.2	88.4	0	435.6	7.26
P3	4682	21,925	522.4	60.0	59.2	641.6	10.69
Total	4196	15, 364	371.7	65.5	5.4	442.6	7.38

50 Yard Freestyle Analyses

Descriptive Data for 50 Yard Freestyle

Mean baseline and post 50 yard freestyles times, as well as associated gains during training, are reported by training program in Table 4.4. In this sample, Program 3 (P3) clearly showed the greatest gain (improvement) followed by P1 and P2, respectively, with a slight edge of P1 over P2. The mean gain over baseline time was 5.16% for all programs combined.

ANOVA #1: 50 Yard Free Post Times by Training Program

A one-way analysis of variance (ANOVA) was conducted on 50 yard freestyle post times. Per Table A-1, no significant differences were found in 50 yard post times.

Table 4.4
Mean 50 Yard Freestyle Times: Baseline, Post and Gain

Training Program		Baseline 50 Yard Freestyle Time	Post 50 Yard Freestyle Time	Gain in 50 Yard Freestyle Time
Swim Only	Mean	31.19	29.67	1.52
	N	20	20	20
	Std. Deviation	5.63	3.64	2.32
Swim Plus Dry Land	Mean	30.75	29.34	1.41
	N	59	59	59
	Std. Deviation	4.63	3.50	1.60
Swim, Dry Land, Weights	Mean	31.05	27.92	3.12
	N	8	8	8
	Std. Deviation	6.72	2.87	4.62
Total	Mean	30.88	29.29	1.59
	N	87	87	87
	Std. Deviation	5.01	3.473	2.21

ANOVA #2: 50 Yard Free Gain Times by Training Program

Similarly, a one-way ANOVA (Table A-2) was performed on gains in 50 yard freestyle swim times from baseline to post. Here, too, no significant differences were found between the means of the training programs.

50 Yard Freestyle Time Standardizing Method

The study times were standardized using United States Swimming (USS) time standards, which are based on stroke, gender and age. Such time standards are commonly used to set qualifying benchmarks for the various meets conducted by USS and their state affiliates. The standard chosen for this study was the “AAAA” level (Table 4.5), the highest of six age-group and gender standards. This level was chosen because no subject swimmer had achieved this standard prior to the study, nor was any likely to do so by the end of the study. AAAA times are in the range of High School State Record times for most states. The following equation “standardizes” a time for age and gender. A single “standardized swim time” is actually the percent improvement achieved by a swimmer. A swimmer’s gain, from baseline swim to post swim, is compared to the difference between that swimmer’s baseline swim and AAAA time standard. See Equation 1.

Table 4.6 reports the means and standard deviations for standardized 50 yard freestyle times by training program.

Table 4.5

United States Swimming (USS) AAAA Time Standards (2009-2012)

Gender	Age	50 Yard Freestyle	100 Yard Freestyle
Female	13-14	25.09	54.39
Male	13-14	22.99	50.29
Female	15-16	24.49	53.19
Male	15-16	22.19	48.29
Female	17-18	24.29	52.39
Male	17-18	21.49	46.89

Standards shown are for scy (short course yards - 25 yard pool).

Source: USA Swimming. (2008).
2009-2012 A/B National Age Group Motivational Times.
Retrieved September 1, 2013, from:
http:/www.usaswimming.org

An individual swimmer’s standardized time in the 50 yard freestyle is determined by:

$$\text{Standardized Time} = \frac{(\text{Baseline50FR} - \text{Post50FR})}{(\text{Baseline50FR} - \text{AAAA50FR})} \times 100\% \qquad (1)$$

Table 4.6
Mean 50 Yard Freestyle Standardized Swim Time: By Training Program

Training Program	Mean	N	Std. Deviation
Swim Only	14.64	20	12.79
Swim Plus Dry Land	17.72	59	16.21
Swim, Dry Land and Weights	27.60	8	20.61
Total	17.92	87	16.10

ANOVA #3: 50 Yard Free Standardized Times by Training Program

A one-way ANOVA was run on the standardized 50 yard free swim times. A Levene test on the Homogeneity of Variances (HOV) revealed that homogeneity of variance could be assumed (p = .186). No significant difference was found between the means of the training programs (p = .155) as shown in Table A-3.

50 Yard Free Covariate Data: Gender, Age, Experience

Baseline, post, and gain times (from baseline to post) in the 50 yard free, by gender, are reported in Table 4.7. It is readily apparent that gender is a justifiable covariate, particularly in gain times. Male mean gains exceeded female gains by 62%.

Table 4.7
Mean 50 Yard Freestyle: Baseline, Post and Gain Times: By Gender

Gender		Baseline 50 Yard Freestyle Time	Post 50 Yard Freestyle Time	Gain in 50 Yard Freestyle Time
Female	Mean	31.51	30.26	1.25
	N	49	49	49
	Std. Deviation	4.90	3.28	1.38
Male	Mean	30.06	28.03	2.03
	N	38	38	38
	Std. Deviation	5.77	3.35	2.93
Total	Mean	30.88	29.29	1.59
	N	87	87	87
	Std. Deviation	5.01	3.47	2.21

Similar data are reported by age (13 through 17 years) in Table 4.8. Baseline and post times in the 50 freestyle for age 13 were 10-13% higher than the total mean, while those times for age 17 were 11% lower than the overall mean. Gain times had the greatest variability compared to the total mean. Age 13 was 70% greater; age 14 was 35% less; and age 17 had a 13% lower gain. Age is, therefore, justified as a covariate.

Table 4.8
Mean 50 Yard Freestyle: Baseline, Post and Gain Times: By Age

Age		Baseline 50 Yard Freestyle Time	Post 50 Yard Freestyle Time	Gain in 50 Yard Freestyle Time
13	Mean	34.92	32.21	2.71
	N	12	12	12
	Std. Deviation	5.96	4.00	2.58
14	Mean	30.85	29.81	1.04
	N	18	18	18
	Std. Deviation	3.50	2.43	1.26
15	Mean	30.26	28.79	1.47
	N	25	25	25
	Std. Deviation	4.66	3.42	1.75
16	Mean	30.54	28.90	1.64
	N	25	25	25
	Std. Deviation	4.89	3.21	2.64
17	Mean	27.48	26.10	1.38
	N	7	7	7
	Std. Deviation	5.47	2.73	3.16
Total	Mean	30.88	29.29	1.59
	N	87	87	87
	Std. Deviation	5.01	3.47	2.21

The same three swim time measures are displayed by years of competitive swimming experience in Table 4.9. Baseline 50 free swim times for those with 0 and 1 year of experience were 27% and 20% slower, respectively, than the overall mean. At the same time, their gains from baseline were 16.2% and 10.5% compared to an overall mean improvement over base of 5.2%. All other gains were in the range of 2.5% to 4.5%. These variations support years of competitive experience as a covariate.

Table 4.9
Mean 50 Yard Freestyle Baseline, Post and Gain Times: By Years of Competitive Swim Experience

Years of Experience		Baseline Time	Post Time	Gain Time
None	Mean	39.10	32.76	6.34
	N	7	7	7
	Std. Dev.	4.28	2.97	3.46
1 Year	Mean	37.18	33.28	3.90
	N	5	5	5
	Std. Dev.	7.58	4.30	3.58
3 Years	Mean	31.78	30.34	1.44
	N	14	14	14
	Std. Dev.	3.26	2.62	1.51
5 Years	Mean	30.51	29.22	1.28
	N	19	19	19
	Std. Dev.	4.18	3.62	1.11
≥ 7 Years	Mean	28.63	27.91	.72
	N	42	42	42
	Std. Dev.	3.39	2.82	.83
Total	Mean	30.88	29.29	1.59
	N	87	87	87
	Std. Dev.	5.01	3.47	2.21

Table 4.10 displays mean standardized 50 free times by years of competitive swim experience. The value in the denominator (difference between baseline and AAAA times) of the standardized time formula was expected to be large for novice swimmers. Conversely, the denominator was expected to be smaller for more experienced swimmers. The numerator (gain from baseline to post) was expected to be larger for novices and then gradually decrease with increases in experience. The expectation for the standardized time, then, was a high value for beginners and steadily declining values as the level of experience increased. The means in Table 4.10 indicate under-achievement for those in the 3 years category and over-achievement for swimmers in the 5 years of experience category. This tends to validate competitive swim experience as a covariate.

Table 4.10
Mean Standardized 50 Yard Freestyle Time: By Years of Competitive Experience

Competitive Swimming Experience	Mean	N	Std. Deviation
No Experience	36.52	7	12.90
1 Year	28.16	5	8.79
3 Years	15.57	14	13.75
5 Years	20.45	19	21.43
7 or More Years	13.23	42	12.28
Total	17.92	87	16.10

ANCOVA #1: 50 Yard Free Post Times by Training Program

Means for post 50 freestyle times by training program are displayed in Table 4.4. A Levene's test of equality of error variances was conducted and indicated that homogeneity of variance could be assumed (p = .082).

An ANCOVA test of between-subjects effects was performed. The results are displayed in Table 4.11. There was no significant differences in post 50 yard freestyle swim times between training programs after controlling for the effects of gender, age, swim yards, and experience, $F(2,80) = 1.40$, $p = .252$. About 47.6% of the variance in 50 yard post swim times is explained by the model. Years of competitive experience accounts for about 15% of the total variance.

Table 4.11
Tests of Between-Subjects Effects: Dependent Variable: Post 50 Yard Freestyle Time

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	531.79[a]	6	88.63	14.02	.000	.51
Intercept	1027.67	1	1027.67	162.54	.000	.67
Gender	83.27	1	83.27	13.17	.000	.14
Age	23.41	1	23.41	3.70	.058	.04
Total Swim Yds.	87.35	1	87.35	13.82	.000	.15
Yrs. Experience	101.16	1	101.16	16.00	.000	.17
Program#	17.71	2	8.86	1.40	.252	.03
Error	505.80	80	6.32			
Total	75651.79	87				
Corrected Total	1037.59	86				

a. R Squared = .513 (Adjusted R Squared = .476)

The adjusted values of the group means are found in Table A-4. Consistent with the insignificant ANCOVA result, the adjusted means for each training program differ by a fraction over a second or less.

ANCOVA #2: 50 Yard Free Gain Times by Training Program

Means for gains in 50 yard freestyle times from baseline to post are presented by training program in Table 4.4. A Levene's test of equality of error variances was conducted and indicated that homogeneity of variance could be assumed ($p=.09$).

An ANCOVA test of between-subjects effects was performed. The results are displayed in Table 4.12. There was a significant effect of training programs on the post

50 free times after controlling for the effects of gender, age, swim yards, and experience, F(2,80) =6.17, p = .003. Approximately 52.5% of the variance in the dependent variable is explained by program type and the covariates. Years of competitive experience account for about 31% of the total variance, while training program accounted for about 10%.

Table 4.12
Tests of Between-Subjects Effects: Dependent Variable: Gain in 50 Yard Freestyle Time Baseline to Post

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	235.04[a]	6	39.17	16.81	.000	.56
Intercept	10.96	1	10.96	4.70	.033	.06
Gender	2.70	1	2.70	1.16	.285	.01
Age	1.20	1	1.20	.52	.475	.01
Total Swim Yds.	32.38	1	32.38	13.90	.000	.15
Yrs. Experience	90.65	1	90.65	38.91	.000	.33
Program#	28.76	2	14.38	6.17	.003	.13
Error	186.38	80	2.33			
Total	642.46	87				
Corrected Total	421.41	86				

a. R Squared = .558 (Adjusted R Squared = .525)

The estimated marginal group means are found in Table A-5 while Table A-6 presents pairwise comparisons of these adjusted means. Swimmers trained under Program 3-Swim, Plyometrics plus Weights - made greater gains in the 50 Yard Freestyle (M=3.33, p=.028) than those in the Swim Only (M=1.87) and Swim Plus Plyometrics (M=1.27, p=.001) groups. No differences were found between Program 1 and Program 2 (p = .144). Totals yards swam and years of competitive swimming were significant covariates, while gender and age were not.

ANCOVA #3: 50 Yard Free Standardized Times by Training Program

Standardized 50 yard freestyle times by training program are shown in Table 4.6. A Levene's test of equality of error variances was conducted. The test was not significant (p = .143), indicating that the group variances are homogeneous.

An ANCOVA test of between-subjects effects was performed. The results are displayed in Table 4.13. There was a significant effect of training programs on the standardized 50 free times after controlling for the effects of swim yards and experience, $F(2,82) = 3.10$, $p = .050$. Total swim yards, $F(1,2) = 7.05$, $p = .010$, and competitive swim experience, $F(1,2) = 5.02$, $p = .028$, were significant covariates. Collectively, the model explained 20.3% of the variance in standardized 50 freestyle scores, with both covariates and program type explaining roughly equal shares of the variance.

Table 4.13 *Tests of Between-Subjects Effects: Dependent Variable: Standardized 50 Yard Freestyle Swim Time*

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5347.83[a]	4	1336.96	6.47	.000	.24
Intercept	11444.53	1	11444.53	55.42	.000	.40
Yrs. Experience	1037.36	1	1037.36	5.02	.028	.06
Total Swim Yds.	1456.45	1	1456.45	7.05	.010	.08
Program#	1280.52	2	640.26	3.10	.050	.07
Error	16933.98	82	206.51			
Total	50213.42	87				
Corrected Total	22281.82	86				

a. R Squared = .240 (Adjusted R Squared = .203)

The adjusted values of the group means are found in Table A-7. The adjusted grand mean across programs was 21.07%. Pairwise comparisons of the adjusted training program means are presented in Table A-8. Collectively, the results indicate that adjusted standardized 50 yard freestyle swim scores were more favorable for the Swim, Plyometrics and Weights group (M=30.26) than the Swim Only (M=16.06) and Swim Plus Plyometrics Group (16.87). No significant difference was found between the latter two groups.

100 Yard Freestyle Analyses

Descriptive Data for 100 Yard Freestyle ANOVA's

Baseline and post times, as well as associated gains for the 100 yard freestyle during training, are reported in Table 4.14. In this sample, Program 3 (P3) showed the highest gains (improvement) in seconds (M=10.48) followed by P1 (M=4.63) and P2 (M=2.47), respectively. The mean gain over baseline was 4.74% for all 100 free programs combined, compared to 5.16% for the 50 freestyle across programs.

Table 4.14
Mean 100 Yard Freestyle: Baseline, Post and Gain Times

Training Program		Baseline 100 Yard Freestyle Time	Post 100 Yard Freestyle Time	100 Yard Freestyle Gain Time
Swim Only	Mean	71.44	68.67	2.77
	N	20	20	20
	Std. Deviation	15.27	11.09	4.63
Swim Plus Dry Land	Mean	69.82	66.78	3.04
	N	59	59	59
	Std. Deviation	10.40	9.00	2.47

Table 4.14 (continued)

Training Program		Baseline 100 Yard Freestyle Time	Post 100 Yard Freestyle Time	100 Yard Freestyle Gain Time
Swim, Dry Land and Weights	Mean	70.64	63.77	6.87
	N	8	8	8
	Std. Deviation	18.29	8.96	10.48
Total	Mean	70.27	66.94	3.30
	N	87	87	87
	Std. Deviation	12.33	9.49	4.37

ANOVA #4: 100 Yard Free Post Times by Training Program

A one-way analysis of variance (ANOVA) was conducted on 100 yard freestyle post times. Per Table A-9, the test revealed no significant difference between the means of the Training Programs (p=.459)

ANOVA #5: 100 Yard Free Gain Times by Training Program

First, a Levene test on the Homogeneity of Variances (HOV) was significant (p = .000), violating the assumption of equality of variance in group means. Thus, the results should be interpreted with caution. With that in mind, a one-way ANOVA found no significant difference between the means of the training programs using an F test (p = .052) as shown in Table A-10.

100 Yard Freestyle Time Standardizing Method

The 100 yard freestyle study times were standardized using United States Swimming (USS) time standards (Table 4.5) in the same manner as were the 50 freestyle times using Equation 1. The following equation "standardizes" a participant's 100 yard freestyle time for age and gender.

$$\text{Standardized Time} = \frac{(\text{Baseline100FR} - \text{Post100FR})}{(\text{Baseline100FR} - \text{AAAA100FR})} \times 100\% \qquad (2)$$

Table 4.15 reports the means (M's) and standard deviations (SD's) for standardized 100 yard freestyle times by training program. The most favorable mean was found for Program 3 (M=23.71), while the least favorable one was revealed for Program 1 (M=10.03).

Table 4.15
Mean Standardized 100 Yard Freestyle Swim Time

Training Program	Mean	N	Std. Deviation
Swim Only	10.03	20	8.41
Swim Plus Dry Land	17.84	59	12.67
Swim, Dry Land and Weights	23.71	8	19.85
Total	16.58	87	13.11

ANOVA #6: 100 Yard Free Standardized Times by Training Program

A one-way ANOVA was run on the standardized 100 yard free swim times. A Levene's test on the Homogeneity of Variances (HOV) was significant (p = .006), indicating violation of the assumption of homogeneity of variance. In addition, a significant difference was found between the means of the Training Programs (p = .018) as shown in Table A-11. Given the significance of the Levene's test, Dunnett's T3 tests were run for post hoc multiple comparisons. The Dunnett's T3 tests (Table A-12) revealed a significant difference in the means between training program 2 and program 1 (p = .009), with P2 mean scores more favorable than those representing P1.

100 Yard Free Covariate Data: Gender, Age, Experience

Baseline, post, and gain times (from baseline to post) in the 100 yard free, by gender, are reported in Table 4.16. It is apparent, as it was for the 50 free, that gender is a justifiable covariate, particularly in gain times. Here the male mean gain exceeded the female mean gain by 78%.

Similar data are reported by age (13 through 17 years) in Table 4.17. The 100 Free baseline and post times for age 13 were 12-15% higher than the total mean, while those times for age 17 were 9-12% lower than the overall mean. Gain times had the greatest variability compared to the total mean. Age 13 was 66% greater, while age 14 was 85% less. Age is therefore justified as a covariate.

Table 4.16
Mean 100 Yard Freestyle: Baseline, Post and Gain Times: By Gender

Gender		Baseline 100 Yard Freestyle Time	Post 100 Yard Freestyle Time	100 Yard Freestyle Gain Time
Female	Mean	70.88	68.39	2.48
	N	49	49	49
	Std. Deviation	9.60	8.32	2.11

Table 4.16 (continued)

Gender		Baseline 100 Yard Freestyle Time	Post 100 Yard Freestyle Time	100 Yard Freestyle Gain Time
Male	Mean	69.48	65.06	4.42
	N	38	38	38
	Std. Deviation	15.26	10.63	6.03
Total	Mean	70.27	66.94	3.33
	N	87	87	87
	Std. Deviation	12.33	9.49	4.37

Table: 4.17
Mean 100 Yard Freestyle: Baseline, Post and Gain Times:
By Age

Age		Baseline 100 Yard Freestyle Time	Post 100 Yard Freestyle Time	100 Yard Freestyle Gain Time
13	Mean	80.80	75.26	5.54
	N	12	12	12
	Std. Dev.	17.06	13.09	5.55
14	Mean	69.48	67.69	1.79
	N	18	18	18
	Std. Dev.	7.96	7.344	1.31
15	Mean	67.92	65.42	2.50
	N	25	25	25
	Std. Dev.	8.80	7.80	1.70
16	Mean	69.80	65.96	3.84
	N	25	25	25
	Std. Dev.	12.35	8.69	4.88
17	Mean	64.29	59.65	4.64
	N	7	7	7
	Std. Dev.	16.06	7.85	9.07
Total	Mean	70.27	66.94	3.33
	N	87	87	87
	Std. Dev.	12.33	9.49	4.37

The same three means of swim time are disaggregated by years of competitive swimming experience and displayed in Table 4.18. Baseline 100 free swim times for those with 0 or 1 year of experience were 26% and 25% slower respectively than the overall mean. At the same time, their gains from baseline were 11.3% and 8.7% compared to an overall mean improvement over base of 4.7%. All other gains were in the range of 3.0% to 5.7%, thus justifying years of competitive experience as a covariate. Table 4.19 displays mean standardized 100 freestyle times disaggregated by years of competitive swim experience. The pattern indicates that standardized scores decline as years of competitive swim experience increase. Therefore, years of competitive experience serves as a covariate in the forthcoming ANCOVA.

Table 4.18
Mean 100 Yard Freestyle: Baseline, Post and Gain Time: By Years of Competitive Swim Experience

Years of Experience		Baseline Time	Post Time	Gain Time
None	Mean	88.67	78.65	10.02
	N	7	7	7
	Std. Dev.	9.60	6.27	9.70
1 Year	Mean	88.2	80.50	7.71
	N	5	5	5
	Std. Dev.	22.52	15.78	7.76
3 Years	Mean	72.52	68.42	4.10
	N	14	14	14
	Std. Dev.	8.93	7.00	3.21
5 Years	Mean	68.90	66.60	2.22
	N	19	19	19
	Std. Dev.	8.67	8.19	1.39
≥ 7 Years	Mean	64.93	62.99	1.94
	N	42	42	42
	Std. Dev.	8.31	7.15	1.87
Total	Mean	70.27	66.94	3.33
	N	87	87	87
	Std. Dev.	12.33	9.49	4.37

Table 4.19 *Mean Standardized 100 Yard Freestyle Time: By Years of Competitive Experience*

Years of competitive swimming experience	Mean	N	Std. Deviation
No Experience	22.55	7	16.75
1 Year	20.80	5	12.01
3 Years	17.45	14	10.74
5 Years	15.68	19	14.78
7 or More Years	15.20	42	12.74
Total	16.58	87	13.12

ANCOVA #4: 100 Yard Free Post Times by Training Program

Means for post 100 yard freestyle times are presented in Table 4.14. In this sample, the mean post times decrease from P1 through to P3. A Levene's test of equality of error variances was conducted and was insignificant (p = .093), indicating that the group variances can be assumed to be homogeneous.

An ANCOVA test of between-subjects effects was performed. The results are displayed in Table 4.20. There was no significant effect of training programs on the post 100 free times after controlling for the effects of gender, age, swim yards, and experience, F(2,80) =2.26, p = .111.

Table 4.20
Tests of Between-Subjects Effects:
Dependent Variable: Post 100 Yard Freestyle Time

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3917.21[a]	6	652.87	13.67	.000	.51
Intercept	5754.70	1	5754.70	120.48	.000	.60

Table 4.20 (continued}

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Gender	186.08	1	186.08	3.90	.052	.05
Age	149.45	1	149.45	3.13	.081	.04
Total Swim Yds.	678.44	1	678.44	14.20	.000	.15
Yrs. Experience	1001.77	1	1001.77	20.97	.000	.21
Program#	216.29	2	108.14	2.26	.111	.05
Error	3821.14	80	47.76			
Total	397547.61	87				
Corrected Total	7738.35	86				

a. R Squared = .506 (Adjusted R Squared = .469)

The adjusted means of the post 100 freestyle time by training program are found in Table A-13. Again, no significant difference was found between these values.

ANCOVA #5: 100 Yard Free Gains by Training Program

Means for gains in 100 yard freestyle times from baseline to post are presented in Table 4.14. In this sample, the highest mean gain was made by swimmers trained under Program 3 (M=6.87 seconds).

A Levene's test of equality of error variances revealed that the assumption of homogeneity of variance was violated (p=.002). Thus, Dunnett's T3 was utilized for post hoc comparisons.

An ANCOVA test of between-subjects effects was performed. The results are displayed in Table 4.21. There was a significant effect of training programs on the post 100 free times after controlling for the effects of gender, age, swim yards, and experience, F(2,80) =5.11, *p* = .008. Approximately 39.6% of the variance is explained by the variables in the model. Training programs accounted for 9.5% of the total variance while years of competitive experience accounted for 17.5%.

Table 4.21
Tests of Between-Subjects Effects:
Dependent Variable: 100 Yard Freestyle Time Baseline to Post

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	718.13[a]	6	119.69	10.38	.000	.44
Intercept	8.57	1	8.57	.74	.391	.01
Gender	23.62	1	23.62	2.05	.156	.02
Age	18.09	1	18.09	1.57	.214	.02
Total Swim Yds.	115.86	1	115.86	10.05	.002	.11
Yrs. Experience	216.70	1	216.70	18.80	.000	.19
Program#	117.76	2	58.88	5.11	.008	.11
Error	922.00	80	11.52			
Total	2604.73	87				
Corrected Total	1640.13	86				

a. R Squared = .438 (Adjusted R Squared = .396)

Displayed in Table A-14 are the adjusted values of the group means for 100 free gains. Post-hoc pairwise comparisons of 100 free gains (Table A-15) revealed a significant difference between training program 3 and both program 1 (p = .012) and program 2 (p = .002). Program 1 and program 2 did not differ significantly (p = .553). In other words, swimmers in Program 3 made greater mean gains (M=7.11) than swimmers in Program 1 (M=3.35) and Program 2 (M=2.81) after controlling for gender, age, total swim yards, and years of competitive swim experiences. Total swim yards (p = .002) and years of competitive swim experience (p = .000) were significant covariates, while gender and age were not.

ANCOVA #6: 100 Yard Free Standardized Times by Training Program

Means for standardized 100 yard freestyle times are shown in Table 4.15. In this sample, the most favorable standardized times were found for Program 3 (M=23.71), while the lowest mean was for swimmers in Program 1 (M=10.03).

An ANCOVA test of between-subjects effects was performed. The results are displayed in Table 4.22. There was a significant effect of training programs on the standardized 100 free times after controlling for the effects of swim yards and years of competitive swim experience, $F(2,82) = 4.27$, $p = .017$. Neither covariate was significant. Only 9.0% of the variance is explained by model, all of which was attributable to the type of training program.

Table 4.22
Tests of Between-Subjects Effects:
Dependent Variable: Standardized 100 Yard Freestyle Swim Time

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1959.74[a]	4	489.93	3.13	.019	.13
Intercept	3933.08	1	3933.08	25.13	.000	.24
Yrs. Experience	42.87	1	42.87	.27	.602	.00
Total Swim Yds.	342.45	1	342.45	2.19	.143	.03
Program#	1336.92	2	668.46	4.27	.017	.09
Error	12833.32	82	156.50			
Total	38713.38	87				
Corrected Total	14793.06	86				

a. R Squared = .132 (Adjusted R Squared = .090)

The adjusted values of the group means are displayed in Table A-16. Post-hoc pairwise comparison results for 100 free standardized times are reported in Table A-17 and revealed a significant difference between training program 1 and both program 2 (*p* = .035) and program 3 (*p* = .008). Program 2 and program 3 did not differ significantly (*p* = .123). Specifically, after controlling for years of competitive swimming experience and total swim yards, higher mean standardized 100 Yard Freestyle times were more favorable for swimmers in Program 3 (M=25.07) than those in Program 2 (M=17.50) and Program 1 (M=10.48)

Regression Analyses

Four separate simple linear regression analyses were performed using IBM SPSS 21 software. The 4 different dependent or criterion variables were 50 free gain time, 100 free gain time, 50 free post time and 100 free post time. For each analysis, 4 independent variables (predictors) were utilized. Gender and Age were used as predictor variables in each analysis. Baseline Swim Time and either Total Swim Yards or Total Swim Minutes were also predictor variables in the Gain Time analyses. The other 2 predictors in Post Time analyses were Total Swim Minutes and Years of Competitive Experience.

Regression #1: Gain in 50 Yard Freestyle Time

The four independent variables/predictors in the 50 yard freestyle gain time analysis include total swim yards, gender, age, and baseline 50 freestyle time. The F-ratio in the Table A-18 indicates that the model significantly predicts gains in 50 yard freestyle time, $F(4,82) = 63.40$, $p = .000$. The model summary in Table A-19 reports that R^2 for the model was .756, while the adjusted R^2 was .744. This means that 74.4% of the variance in the dependent variable (50 freestyle gain time) can be explained by the independent variables.

Per Table A-20, three of the four predictor variables were significant, $p < .05$. Total swim yards was the lone exception. The formula predicts the result of 50 free baseline time minus post time. The total swim yards coefficient was negative and so small, that any subject swimming the mean of 200,000 training yards would only gain a predicted - .02 seconds on this basis. The other coefficients were positive, meaning that each alone would contribute positively to a reduction of the constant (-15.631) to arrive at a gain in swim time. A higher baseline time means more room for improvement, hence a higher predicted gain (.390 seconds gain per additional second of baseline time). Likewise, an older swimmer would likely achieve a greater gain (.231 seconds per year of age). For gender, females were coded as "1" and males as "2". The gender coefficient would yield a gain of 1.22 seconds for females and 2.44 seconds for males. The standardized betas reveal the relative power of each independent variable to predict gain times in the 50 Yard Freestyle. For example, Baseline Time (β=.883) is roughly three time more powerful than the next most significant predictor, Gender (β=.275), since .883/.275=3.2.

Regression 1 results are summarized by the following predictor equation:

$$y = (-15.631) + (.390)x_1 + (1.221)x_2 + (.231)x_3 - (1.04\text{x}10^{-7})x_4 \quad (3)$$

y 50 Yard Freestyle Gain Time (sec.)
x_1 Baseline 50 Freestyle Time (sec.)
x_2 Gender (F = 1, M = 2)
x_3 Age (yrs.)
x_4 Total Swim Training Distance (yds.)

Regression #2: Gain in 100 Yard Freestyle Time

The four independent variables/predictors in the 100 yard freestyle gain time analysis include total swim time (minutes), gender, age, and baseline 100 yard freestyle time. The F-ratio in the Table A-21 indicates that the model significantly predicts gains in 100 yard freestyle time, F(4,82) = 41.68, p = .000. The model summary in Table A-22 indicates that 65.4% of the variance in the dependent variable (gain time) can be explained by the independent variables.

As displayed in Table A-23, three of the four predictors in the model added statistical significance to the prediction, $p < .05$. Total swim time (minutes) was again the only exception. The total swim time coefficient was .000 and therefore had no effect. The other coefficients were positive, meaning that each alone would contribute positively to a gain in swim time and overcome the constant (-30.987). A higher baseline time means more room for improvement, hence a higher predicted gain (.301 seconds gain per additional second of baseline time). Likewise, an older swimmer would likely achieve a greater gain (.650 seconds per year of age). Finally, for gender, females were coded as "1" and males as "2". The gender coefficient would yield a gain of 1.995 seconds for females and 3.99 seconds for males. As was the case with the 50 Yard Freestyle Gains, Baseline Time (β=.850) was the most powerful predictor of gains in the 100 Yard Freestyle Time and over three times more powerful than the next most significant predictor, Gender (β=.175).

Regression 2 is summarized by the following predictor equation:

$$y = (-30.987) + (.301)x_1 + (1.995)x_2 + (.650)x_3 + (.000)x_4 \quad (4)$$

y 100 Yard Freestyle Gain Time (sec.)
x_1 Baseline 100 Freestyle Time (sec.)
x_2 Gender (F = 1, M = 2)
x_3 Age (yrs.)
x_4 Total Swim Training Time (min.)

Regression #3: Post 50 Yard Freestyle Time

The four independent variables/predictors in the 50 yard freestyle post time analysis include years of competitive swim experience, gender, age, and total swim time (minutes). The F-ratio in Table A-24 indicates that the model significantly predicts 50 yard freestyle post times, $F(4,82) = 21.18$, $p = .000$. Results in Table A-25 reveal that 48.4% of the variance in the dependent variable (50 Yard Free Post Time) can be explained by the independent variables.

As indicated in Table A-26, all four predictors in the model added statistical significance to the prediction, $p < .05$. The formula predicts post 50 free times. Despite its statistical significance, the total swim time coefficient was .000 and therefore irrelevant compared to the other coefficients. The other coefficients were negative, meaning that each alone would contribute significantly to a reduction in the constant (46.268) to arrive at a post time. An older swimmer would likely achieve a greater reduction (.532 seconds per year of age). For gender, females were coded as “1” and males as “2”. The gender coefficient (-2.015) would yield a reduction of 2.015 seconds for females and 4.030 seconds for males. The coefficient for experience (-.940) would reduce the time by .940 seconds per each additional year of competitive swimming experience. In this model, total swim time (β=-.340) was the most powerful predictor of 50 Yard Freestyle Post Times, followed closely by Gender (β=-.289), and almost double that for Age (β=-.180).

The equation for Regression 3 is summarized as follows:

$$y = (46.268) - (2.015)x_1 - (.532)x_2 - (.000)x_3 - (.940)x_4 \tag{5}$$

y 50 Yard Freestyle Post Time (sec.)
x_1 Gender (F = 1, M = 2)
x_2 Age (yrs.)
x_3 Total Swim Training Time (min.)
x_4 Competitive Swim Experience (year code value)

Regression #4: Post 100 Yard Freestyle Time

The four independent variables/predictors in the 100 yard freestyle post time analysis include years of competitive swim experience, gender, age, and total swim time (minutes). The F-ratio in Table A-27 indicates that the model significantly predicts post 100 yard freestyle times better than chance alone, $F(4,82) = 20.42$, $p = .000$. The model summary in Table A-28 reveals that 47.5% of the variance in the dependent variable (100 yard post time) can be explained by the independent variables.

As revealed in Table A-29, three of the four predictors in the model added statistical significance to the prediction, $p < .05$. Gender was the lone exception, but was just off significance ($p = .068$). The formula predicts post 100 yard free times. All coefficients were negative, meaning that each alone would contribute significantly to a reduction in the constant (110.178) to arrive at a post time. An increase in age will cause a reduction (1.389 seconds gain per year). Likewise, an increase in experience will likely achieve a reduction (2.890 seconds per year). As mentioned previously, females were coded as "1" and males as "2" in the gender classification. The gender coefficient would yield a reduction of 2.837 seconds for females and 5.674 seconds for males. Finally, the total swim time coefficient would also lead to a reduction (.001 seconds per minute). Total swim time in minutes (β=-.360) and years of competitive swimming experience (β=-.387) were relatively equal in predictive power and roughly twice as powerful as age (β=-.179).

The Regression 4 equation is summarized as follows:

$$y = (110.178) - (2.837)x_1 - (1.389)x_2 - (.001)x_3 - (2.890)x_4 \quad (6)$$

y 100 Yard Freestyle Post Time (sec.)
x_1 Gender (F = 1, M = 2)
x_2 Age (yrs.)
x_3 Total Swim Training Time (min.)
x_4 Competitive Swim Experience (year code value)

Summary of Results

In summary, six ANOVA's were performed. Post, gain and standardized times for 50 and 100 freestyle served as the dependent variables, while the type of training program was the independent variable. Only one analysis found significant differences between training programs. This was for the 100 freestyle Standardized Time ($p = .009$) favoring P2 over P1.

Four ANCOVA's, involving 50 and 100 yard free Post Time and Gain Time as dependent variables, were performed. The covariates for all four analyses were Gender, Age, Total Swim Yards and Years of Competitive Experience. Among these four variables, Competitive Experience explained the greatest source of variance. The 50 and 100 free Post Time ANCOVA's proved not to be significant. On the other hand, significance was found in the 50 and 100 free Gain Time ANCOVA's, with significant differences between means of P3 and both P1 and P2. All differences favored P3.

The other two ANCOVA's involved 50 and 100 free Standardized Time as the dependent variable. Since Standardized Time is "standardized" against Gender and Age, only Total Swim Yards and Years of Competitive Experience were used as covariates. The standardized 50 free analysis proved to be non-significant, but just marginally so. There were significant differences in training means between P3 and both P1 and P2 (favoring P3). On the contrary, the standardized 100 free analysis was found to be significant. This time there were significant differences in training means between P1 and both P2 and P3 (favoring P2 and P3).

The regression analyses were successful in developing prediction equations for 50 and 100 freestyle Gain Times and 50 and 100 free Post Times using much of the collected training data (Gender, Age, Baseline Times, Total Swim Yards, Total Swim Minutes and Years of Competitive Experience).

CHAPTER V

DISCUSSION

The purpose of this study was to test the effect of three training interventions (programs) on sprint freestyle time trials (at 50 and 100 yards) among competitive high school swimmers. The post swim times and gains in swim times at these distances, from baseline time trial to post time trial, were the original dependent variables. The percent gain was found by dividing gain time by baseline time. Dependent variables added during study analyses were "standardized" swim time gains at the same distances. For an individual swimmer, a standardized time gain was defined as their actual gain time from baseline to post divided by the difference between their USS AAAA time standard and their baseline time. This was considered a measure of a swimmer's percent gain toward achievement of an AAAA time standard. The use of this time standard, based on gender and age, was intended to minimize the effects of these two variables on calculated swimming improvement. Finally, regression analyses developed predictor equations for post training times and gain times in the 50 and 100 yard freestyles, making them the final dependent variables.

The independent variables for the means comparisons were the (three) training programs—Swim Only (P1), Swim plus Plyometrics (P2), and Swim plus Plyometrics and Weights (P3). Gender, age, years of competitive swimming experience, total swim minutes, total swim yards, 50 free baseline swim time and 100 free baseline swim time served as covariates. Predictor variables included age, gender, total swim yards, years of competitive experience, total swim minutes, and baseline (initial time trial) swim times.

Influence on Gain by Categorical Variables: Gender, Age, Experience

Performances in response to training were disaggregated by gender, age and years of competitive experience in the combined programs but not by individual program. The effects of these three variables were controlled in later ANCOVA tests.

Figure 5.1 demonstrates the difference in gains achieved by female and male subjects. When combining the 50 and 100 freestyle results, male swimmers improved overall by 6.56%, while female swimmers had an average gain of 3.74%. The male to female improvement ratio is about 1.75 to 1 and is possibly due to different physiological responses between the genders to training programs. It will be seen later that regression predictor equations used a flat 2:1 ratio.

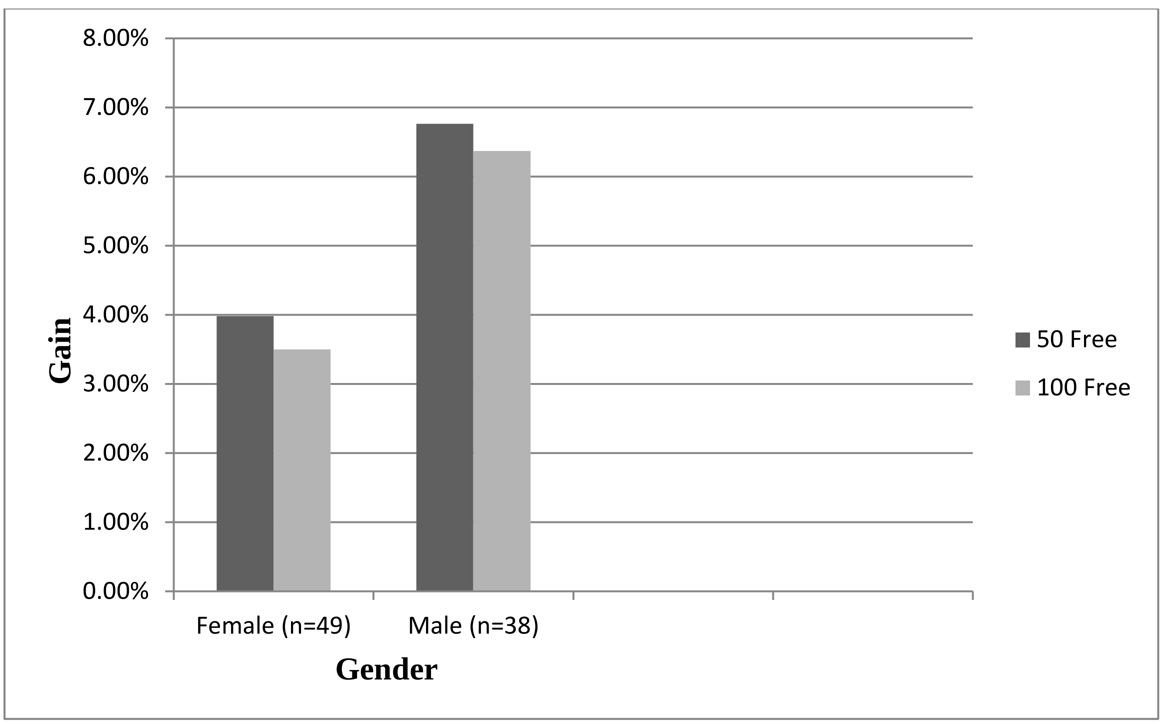

Figure 5.1. *Gain by Gender.*

Improvements by age groups in the total study can be seen in Figure 5.2. Here, the trend was for a large improvement at the 13 year-old level (7.3%), followed by a large drop to 3.0% at age 14. From there, a steady increase in improvement was seen, 4.3% at age 15, 5.4% at age 16 and 6.1% at age 17. These numbers represent gains in the 50 and 100 freestyles combined. The gain for 13 year-olds appears to be an irregularity followed by a linear trend of gain increases from ages 14 through 17. Since age and experience increase at the same pace, it would make more sense for this trend to decrease in the same manner as in Figure 5.3, Gain by Competitive Swimming Experience. However, larger gains by older swimmers may be the result of making a greater commitment to the sport since these participants are still swimming at age 17.

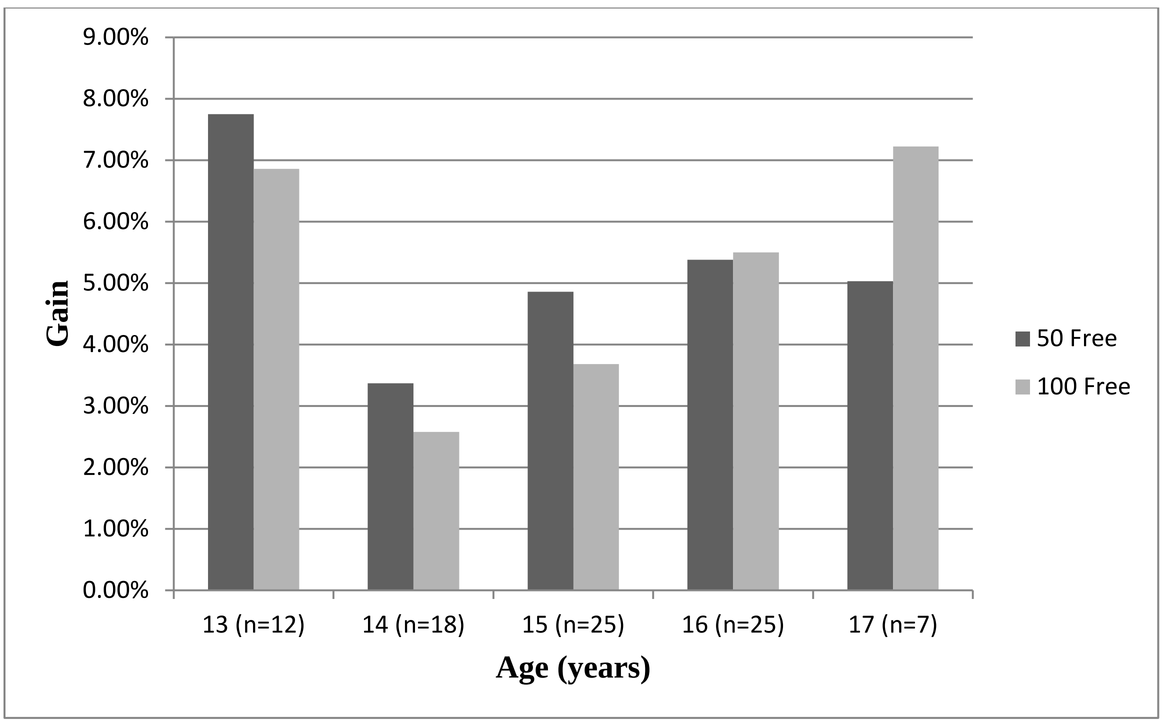

Figure 5.2. *Gain by Age.*

Lastly, gains by level of prior competitive experience were analyzed in total. The categories were 0, 1, 3, 5 and $\geq$ 7 years. By combining the gains in the 50 and 100 freestyles, the gains decreased in approximately linear fashion: 13.8% (0 yrs.), 9.6% (1 yr.), 5.1% (3 yrs.), 3.7% (5 yrs.), and 2.8% ($\geq$7 yrs.) as depicted in Figure 5.3. This seems logical. As swimmers accumulate more experience, their baseline swims from year to year trend naturally downward toward some minimum goal time. Therefore, gains from year to year trend downward and theoretically approach 0.00 seconds.

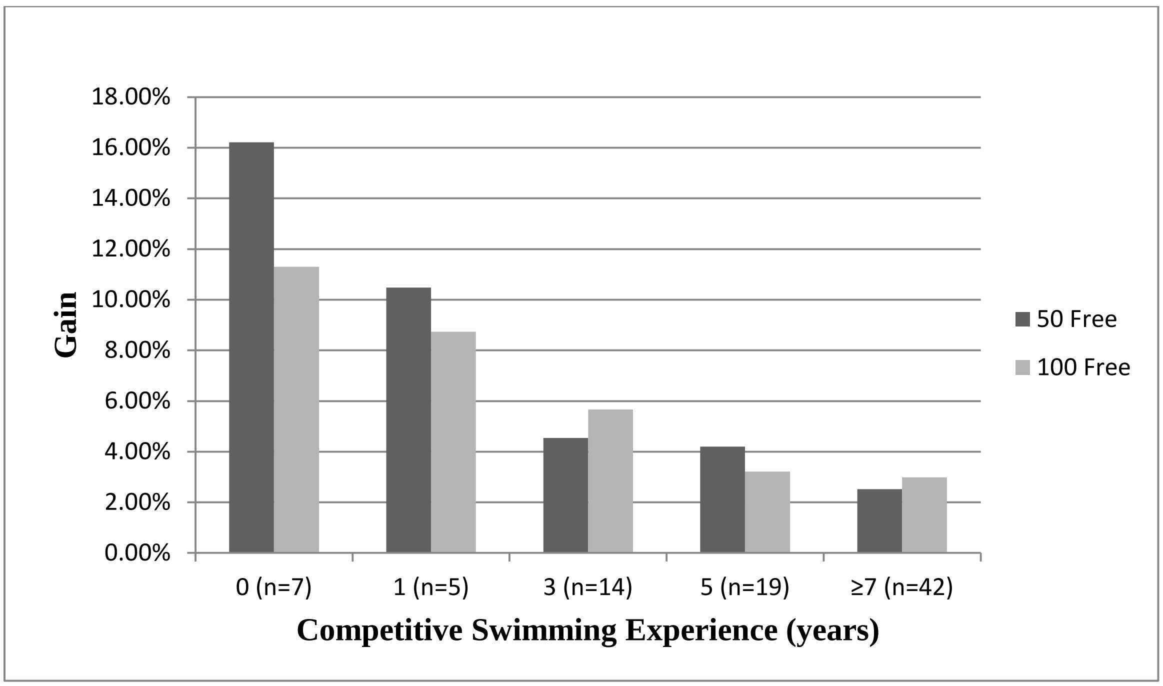

Figure 5.3. *Gain by Competitive Swimming Experience*

The same analysis was performed comparing experience to standardized gain times in Figure 5.4. The standardized gain values are much higher than the non-standardized gain values due to a different calculation method. Standardized gain here equals a swimmer's gain time divided by the gap between the swimmer's AAAA standard time and baseline time. The trend for standardized gain is about the same as in the non-standardized analysis, except that the slope of the plot for standardized gain approaches zero. The percent gains reach a flat or plateau-like level as the gains (in seconds) become more difficult to achieve. In this case, the calculated percent flattened out at about 15%. The non-standardized gains by experience were not controlled for age and gender as were the standardized gains.

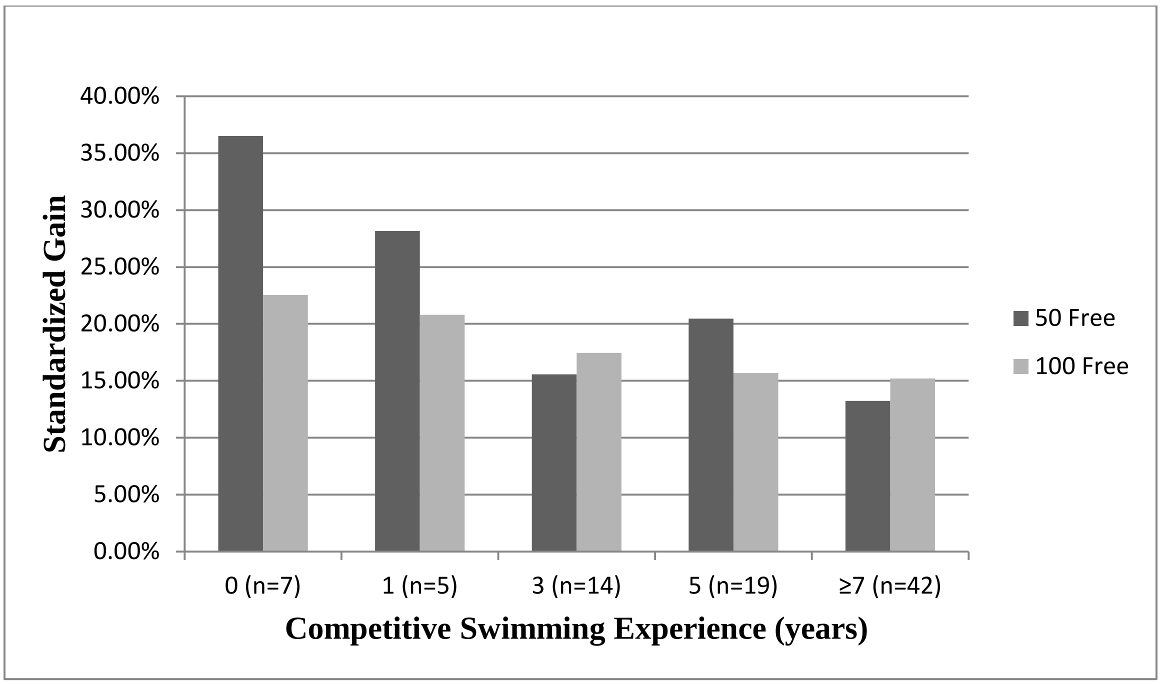

Figure 5.4. *Standardized Gain by Competitive Swimming Experience.*

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Influence on Gain by Training Programs

Without controlling for other variables, and combining the results of the 50 and 100 freestyles for each program, swim time gains of 4.4% for P1, 4.5% for P2 and 9.9% for P3 (Figure 5.5) were achieved. This seems to indicate practically no difference between P1 and P2 training, and that the plyometric training in program P2 had no significant effect. It also appears that program P3 was more effective at increasing gain times than either P1 or P2 because it featured weight training in addition to plyometric training. A closer look, though, indicated that P3 subjects swam about 43% more yards per week on average than P1 and P2 subjects, and exercised about 35% more minutes per week outside the pool than did P2 subjects. So the additional gain produced by program P3 could have been due to extra swimming yardage, due to weight training over and above plyometric training, or due to both.

When 50 and 100 freestyle "standardized" gain times were combined for each program, a different picture emerged. Per Figure 5.6, the improvements increased almost linearly, 12.3% for P1, 17.8% for P2 and 25.7% for P3. This implies that program P2 was more effective than P1 and that program P3 was more effective than P2 and P1. Therefore, the results of this more sophisticated statistical approach should be weighed more heavily than the non-standardized results in Figure 5.5. A summary of all statistical analyses is presented in Table 5.1.

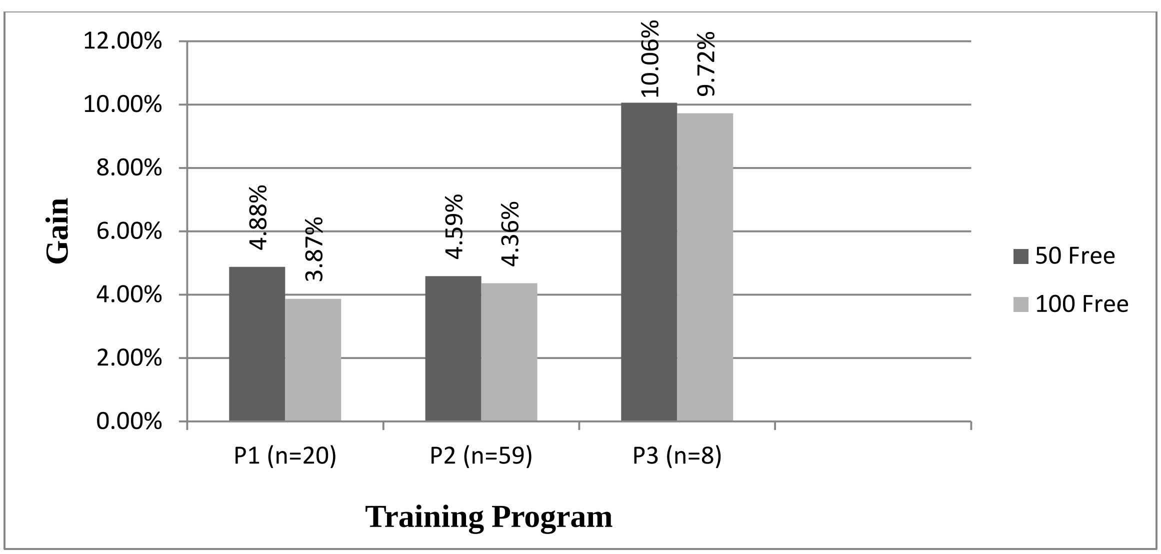

Figure 5.5. Gain by Training Program

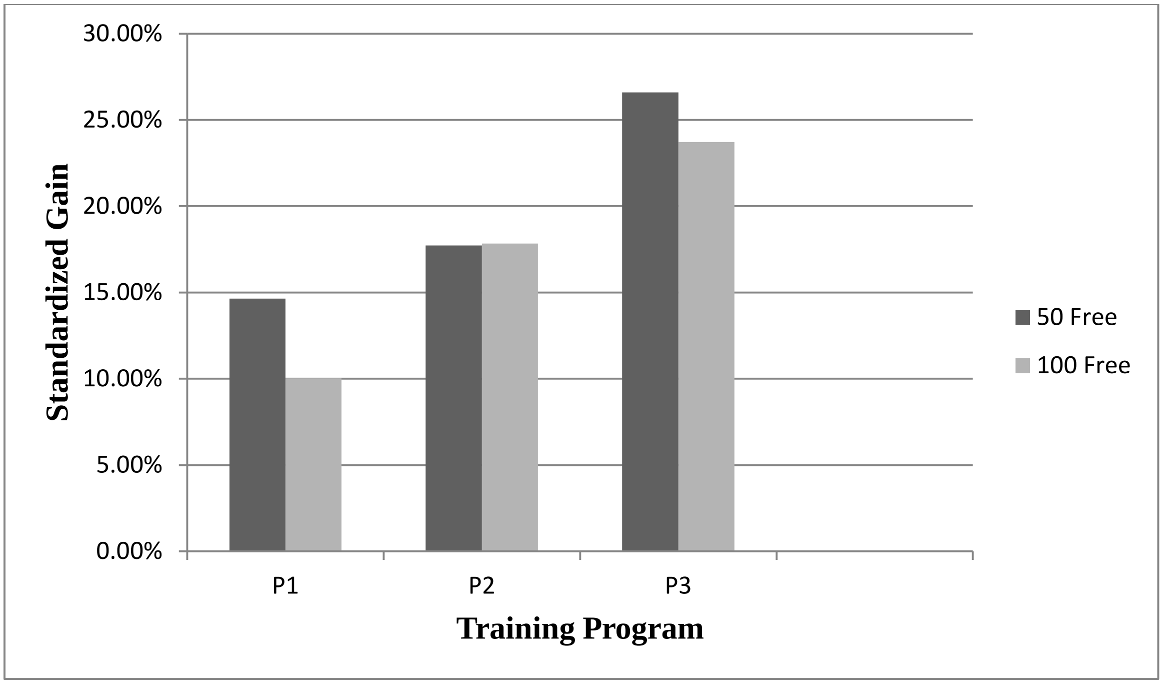

Figure 5.6. *Standardized Gain by Training Program.*

Table 5.1
Summary of Statistical Results

	50 Post	50 Gain	50 Stand.	100 Post	100 Gain	100 Stand.
ANOVA	Not Sig. p = .480	Not Sig. p = .120	Not Sig. p = .155	Not Sig. p = .459	Not Sig. p = .052	Sig. p = .018
Post-Hoc						P2 > P1 *
ANCOVA	Not Sig. p = .252	Sig. p = .003	~ Sig. p = .050	Not Sig. p = .111	Sig. p = .008	Sig. p = .017
Post-Hoc		P3 > P2 * P3 > P1 *	P3 > P1 * P3 > P2 *		P3 > P2 * P3 > P1 *	P3 > P1 * P2 > P1 *

* significant at α = .05 level

Findings from Inferential Tests

In general, it was expected that program P3 (swim plus plyometrics plus weights) would be shown to be superior to program P2 (swim plus plyometrics), which in turn would be indicated as superior to program P1 (swim only). In other words, swim only (habitual) training is still good for novices, swimming coupled with plyometrics is a minimum training standard (especially for pre-teen swimmers), and swimming coupled with plyometrics and weight training is the standard for teenage swimmers and beyond.

It was not surprising that most of the six ANOVA's displayed in Table 5.1 proved to be non-significant. There were five covariates for each of the six independent variables, but only the most important variable, training program, could be compared by ANOVA. The lone significant difference was in the 100 yard standardized gain time. Standardizing for age and gender in essence controls for these two variables while executing a one-way ANOVA, making it a more powerful analysis. Given that the highest standardized gain time was earned by swimmers trained under P3, it was unforeseen that program P3 would not be shown to be significantly better than both the other programs. This lack of significance was attributable to the low N size of swimmers in P3. Further, it was a little surprising to find no significant difference in 50 yard standardized gain time. It is possible that the greater distance yields more opportunity for improved times.

The lack of significance in the 50 and 100 yard post time ANCOVA's was not unpredicted. These analyses controlled for age, gender, total swim yards and years of competitive experience. Controlling post times for baseline times might have revealed something useful about training effects but would have yielded little variance left to explain.

ANCOVA's for 50 and 100 gain times were significant as expected, as were the covariates swim yards and years of experience. When standardizing these same gain times, the ANCOVA's were again significant as presumed, but the significance of covariates was mixed. The covariates swim yards and years of experience remained significant for the 50 standardized gain time but were insignificant for the 100 standardized gain time. The opposite was expected because practice yardage and prior experience are assumed to be more beneficial for longer distances.

Post hoc comparisons for 50 gain, 50 standardized gain and 100 gain produced the expected results: program P3 was significantly better than either program P1 or P2. For the 50 gain and 100 gain, program P2 was slightly more effective than program P1 as expected. For the 50 standardized gain, program P1 was shown to be slightly superior to program P2. This was unexpected. Post-hoc comparisons for 100 standardized gain yielded expected results. Program P3 was significantly better than program P1, P2 was significantly better than P1, and P3 was slightly better than P2. The one significant ANOVA and four significant ANCOVA's yielded the following findings:

* P3 > P1 (4 Post hoc comparisons after 4 significant ANCOVA's)

* P3 > P2 (3 Post hoc comparisons after 4 significant ANCOVA's)

* P2 > P1 (2 Post hoc comparisons after 1 ANOVA and 4 ANCOVA's)

* statistically significant at the .05 level

As expected, training program P3 was shown to be clearly superior to programs P1 and P2. Program P2, on the other hand, was not shown to be distinctly superior to P1 as expected. It was moderate at best. A possible cause includes improper targeting of muscles, resulting in overworking or underworking the wrong muscles. Another cause could be a lack of understanding of plyometrics on the part of the coach, resulting in inadequate instruction and improper execution by the participants. Further study is warranted.

Another interesting question, not considered in the current study, concerns the greater gains achieved by male swimmers compared to female swimmers. The ratio of mean female to male gain times was 0.62 for the 50 free and 0.56 for the 100 free. The average ratio is about 0.59, meaning the females in this study had gain times about 59% of that for the males. Another way to look at it would be to divide the faster male times by the slower female times. This yields 0.95 and 0.93 for baseline and post 50 free times and 0.98 and 0.95 for similar 100 free times. The overall average is 0.958, or about 96%. These numbers look better, but it’s still apparent that the response of female swimmers to training in this study was less than that of the male swimmers. Female gain times were 59% of male gain times, and the male to female swim time ratios dropped from pre to post in the 50 free and 100 free (meaning faster males or slower females or both). The reason possibly could be the effects of maturation. Females mature earlier than males who continue to build muscle mass for several years after cohort females have reached puberty. This topic deserves future study.

Themes Across or Within Research Questions

The most frequently repeated themes involving training interventions include ordinary swim training, plyometric training, weight training and various combinations of all three. Dry land exercises and strength training are terms that were found to refer to either plyometric or weight training, or both. Measuring improvement against pre and post sprint freestyle times was also a recurring theme.

Plyometric training and weight training have different purposes, yet in some cases they overlap. Chu (1998) includes leg jumps, medicine ball toss, running, pushups and stretch cords among many plyometric exercises. Their purposes are to improve general conditioning, to stretch appropriate muscles prior to swim workouts, to maintain overall fitness and to improve power output. Weight training, on the other hand, strengthens the core (partially to prevent injury due to repeated muscle use) and improves muscular endurance. This type of training helps to provide explosive starts off the blocks and quick turns off the walls. Included are the use of free weights, weight machines (lat pulls, etc.), push- ups and sit-ups. These exercises produce fast muscle contractions (in fast-twitch muscles) over a short time period. Bompa (1993) recommended medicine ball use during the power phase in training junior athletes. The overlaps are understandable. Another purpose of dry land exercises (plyometrics and weight training included) is to mimic the swim stroke in water. Many researchers have tried to solve this problem. A complication is the fact that water resistance increases with the swimmer's speed (Zatsiorsky, 1995). All teams in this study have used most of the above exercises in their plyometric and weight training sessions.

There is no debate that plyometrics and weight training produce the desired results as mentioned above. However, their effect on improvement of swimming performance is assumed but a little more difficult to prove given the mixed results from previous studies. For example, Aspenes and Karlsen (2012) reviewed 17 controlled interventions. The greatest effect on swim performance found was for a 50 meter freestyle swim following a specific program of elastic resistance exercises and lat pulls.

Tanaka et al. (1993) studied two groups (SWIM and COMBO) of 12 male collegiate swimmers each for a 14-week period. Both groups swam equal amounts. For 8 weeks, the COMBO group performed resistance training exercises designed to simulate swimming muscle actions. The result was significant, with similar power gains in each group, but no significant difference between groups in swimming performance tests. The researcher blamed the lack of performance improvement on “the specificity of training”. It seems that the described training regimen was specifically geared toward improvement of performance.

Bishop et al. (2009) examined two groups of 11 swimmers with an average age of about 13 years. The HT (habitual swimming) and PT (swimming plus plyometric) groups trained together for 8 weeks. Baseline and post-tests off starting blocks were performed. There was a significant improvement in the PT group for elapsed time over the initial 6 yards and for take-off velocity from the blocks to water contact.

Bradshaw and Hoyle (1993) tested 7 college-age swimmers with at least 3 years of competitive experience. A significant correlation was found between swim power, as measured by a biokinetic swim bench, and arms-only freestyle time for 25 meters. Full-stroke swim time did not correlate significantly. Somewhat consistently, Costill et al.

(1983) found that elite sprinters are able to produce higher peak power in the water than slower swimmers, but that overall accomplishment in the pool depends on a lot more than just strength.

Barber (1998) studied three groups (similar to the training groups in the current study) of females with an average age of about 14 years and average group size of about 12 swimmers. An ANCOVA found no significant difference between the groups on gain times in 25 and 50 yard freestyle time trials. A paired t-test found significant differences from pre to post in Group 3 (swim plus plyometrics plus weights.)

It is clear from prior studies that plyometrics and weights improve overall fitness and strength. It is also well-defined that fitness/power are not the only factors that lead to improvement in swim performance. However, unlike this study, the studies summarized above either did not measure swim time gains as a dependent variable or more often than not did not find significant gains in swim time when they did. The current study has shown that weights in combination with plyometrics and swim training is superior to plyometrics plus swimming and to swim only training in terms of swim time gains. The minimum levels of plyometrics and weight training for time improvement have not been established. Also, there is probably an upper limit or threshold level for these types of interventions that causes improvement to level out or to “plateau.” These latter variables are worthy of future research. Factors that may account for the differences in findings from this study include a sample of high school swimmers as opposed to elite/college swimmers which could result in more room for improvement, a larger sample size with greater power to find differences that exist, and the use of several covariates to control for differences between groups that could have confounded results in previous studies.

Limitations

Sample Size

The total sample (*n* = 87) for this study appears to be more than adequate, at nearly four times the average size (*n* = 24) of the four prior studies frequently referred to in this study. However, the sample size for training program P3 (*n* = 8) is very small. Per Table 3.2, 67.8% of participants were involved in program P2 and only 9.2% in P3. A closer look indicates that the participants in P3 came from four of the five teams represented in the study and four out of five of the possible age groups. However, the group was biased toward males (6 boys, 2 girls). The group makeup appears to be average in competitive experience (M = 5.00 years) compared to the total mean of 5.01 years. However, the group was unbalanced, with two novices and five members with 7 plus years of experience. This situation was not foreseen during the process of enlisting teams for participation and assigning swimmers to training groups. The 8 subjects in P3 represent only 9% of the total sample instead of the ideal 33%. Ideally coaches based their training program recommendations with the best interests of the swimmer in mind. Subconsciously, though, a coach may suggest P3 to swimmers involved in a fall sport that utilizes weight training, such as football, and P2 to those involved in fall soccer or cross country, where general fitness is important. This may have been done in spite of other swimmers having the physical maturation to participate in weight training. The "Matthew Effect" might have come into play where the already good get the best opportunity to get better. Ultimately, though, each swimmer made his/her own decision.

In the future, an attempt should be made to balance out the number of participants in each training program on a team basis and overall basis. It was assumed initially in this study that the large total sample would balance itself out randomly without any selection intervention needed. Despite these differences between groups, it is important to note that mean swim gain differences were found when gender and competitive years of experiences were covariates, thus diminishing concerns about differences in swimmer characteristics between groups.

Self-Reporting of Competitive Swimming Experience

Another possible limitation was the self-reported number of years of competitive swimming experience. First of all, the numerical categories on the questionnaire had gaps. The five possible values were 0, 1, 3, 5 and 7 or more. Values for 2, 4 and 6 years obviously could have been included as well. In some cases, responders had to choose a value either higher or lower than their actual level of experience. Secondly, responses to questions like this can be easily exaggerated. In the future, a complete set of values should be provided. Also, each coach who administers the questionnaires should be required to interview each swimmer and verify the level of experience as thoroughly as possible. This kind of categorical variable is certainly not as verifiable as gender or age. Even though competitive experience was a significant categorical variable, it is unlikely that the above concern compromised the validity of the study. Rounding up one year or down one year most likely balanced out the results because of the large number of participants.

Sharing Pool Time

Due to a scarcity of pools in Kentucky, high school teams must share pool time with USS and YMCA club teams, as well as with college teams and other high school teams. Few high schools have their own pool, though one team in this study was fortunate enough to have one. This leads to a variety in the number of days and/or hours practiced by each team. By extension, this could lead to a variety in total practice yards (minutes), plyometric time, and weight training time.

Effects Due to Taper

Another limitation was taper. All teams tapered a few weeks out from the Regional Meet. The effects on gain time due to taper were not considered.

Coaching

The ability level of the five coaches and the intensity of their assigned workouts were assumed to be constants when in reality they were variables. All of the participating coaches had many years of experience, and all of them coach other teams such as USS teams or club teams. These coaches are certified by the KHSAA and were chosen because of their experience, so it is felt that the validity of the study has not been compromised. In this study, the teams were selected because of the skill of their coaches and their familiarity with the principal investigator. In the past, one head coach served as an assistant to another head coach on a USS age-group team. Two teams shared pool time, which allowed their head coaches to observe one another's coaching techniques and debrief one another. One head coach consistently fields top-ten teams in the state of Kentucky. And one is a year-round swim coach, working with a high school team and USS club team in the winter and coaching the same USS team in the summer season. Swim coaches tend to share written swim workouts, and they all tweak them to suit their own team. In this case, concerns over the ability level of the coaches have been mitigated.

Future studies could require that coaches also be certified by the National Interscholastic Swim Coaches Association (NISCA) or USA Swimming (USS). It is likely that some of the coaches have one or more of these certifications, but it was not documented.

Team Effects and Variance Within Training Programs

This study had the benefit of 87 participants on 5 teams instead of the usual 24 swimmers on a single team. However, this introduces team effects. Several covariates were included in the analyses to control for such differences. As stated above, the quality of "swim" coaching has been standardized reasonably well. However, there is a tendency for a wider variety in the intensity of plyometrics and weight training. One coach uses a self-built "power rack" to simulate an expensive off-the-shelf version. Not all coaches will use the same plyometric exercises or prescribe the same number of repetitions during weight training. In an effort to reduce this variation, the principal investigator has shared with each coach a list of suggested exercises and suggested number of repetitions.

Implications for Policy and Practice

The obvious recommendation for practice that emerged from this study is for coaches to include some form of weight training in their regimens. Coaches are pivotal to improvement for young swimmers, whether they coach a high school program, a USS club team or a summer swim club. Given this critical role, other recommendations for policy and practice focus on coaches and their knowledge base.

Recommendations

1. Require educational units on best practices in plyometrics and weight training. Such education could come from the KHSAA, the National Interscholastic Swim Coaches Association (NISCA), or the National Federation of State High School

Associations (NFHS). These organizations are a perfect fit for high school swim coaches. NISCA sponsors an All-American Swimming and Diving Certificate program, as well as an Academic All-American program for high school aquatic athletes. Among other things, NFHS produces high school swimming, diving and water polo rules that have been adopted by most high school groups, including the KHSAA.

2. Require continuing education units (CEU's) to be completed on an annual or biennial basis. The KHSAA requires some baseline online training, but CEU's would raise the bar a little higher. This could improve the performance and safety of swimmers, who risk injury from improper training.

3. Form an association of high school swim coaches under the sponsorship of the KHSAA. The membership of such a group could be broken down by regions identical to the existing five KHSAA swimming regions. As it stands now, high school coaches seldom meet as a group, and when they do, it is usually at a regional meet to discuss the ground rules and logistics of the meet. The purpose of such an organization could be to share training techniques, successes and failures. Many coaches rely on scholarly papers published in journals or dissertations such as this one. A coaching association could share ideas on a less formal basis by way of guest speakers from within the state of Kentucky or beyond. This concept might be difficult to sell since high school swim coaching is a part-time job that usually pays a modest stipend. Those who teach at the same school they coach are in the minority.

Recommendations for Future Research

The recommendations that follow were compiled based on the results of this study and on ideas developed while reading current literature.

1. Expand on the starting block training studied by Bishop et al. (2009). Add a program of swimming, plyometrics and weights in addition to the swim only and swim plus plyometric training programs of his study. The subjects should be post-adolescent high school swimmers capable of participating in any of the three programs.
2. Formulate a study using assisted/resisted swimming using a “power rack” device. A few high school coaches make their own version because of the cost of the real machine. Study the improvement in performance associated with this device compared to a control group using conventional plyometrics.
3. In future studies of high school swimmers, tie performance to body (anthropometric) measurements (Halet et al., 2009) such as arm length, forearm length, % body fat, lean body mass (LBM), height and weight. Body fat % could be calculated using skin-fold calipers. Alternative methods are the YMCA questionnaire, the US Navy tape measure method or photo comparisons.
4. Adapt and simplify the study of Borresen and Lambert (2008) for high school swimmers. During Saturday practices, measure the heart rate (HR) of selected swimmers at three or more intervals during a swim workout. Require that swimmers estimate their rate of perceived exertion (RPE) using the scale of Borresen and Lambert (2008). In addition, tie HR and RPE to a different workout once per week to get a feel for which workouts are more strenuous and to determine the cumulative effect of exertion on improved performance.
5. Devise a study that includes four training groups of nearly identical size. Assure that each group swims essentially the same total number of yards (and minutes)

per week. Group 1 would spend 15% of its total time on plyometrics and 85% on swimming. Group 2 would spend 30% of its allotted time on plyometrics and the remaining 70% on swimming. Group 3 would spend 85% of its time swimming and 15% of its time on a combined program of plyometrics and weights. Finally, Group 4 would spend 70% of its time swimming and 30% of its time on a combined program of weights and plyometrics. Balance the groups as much as possible according to gender, age and experience. One could analyze Group 1 and Group 2 concerning the effectiveness of plyometrics. Groups 3 and 4 could be analyzed for their effectiveness concerning weight training. And all 4 groups could be analyzed by ANCOVA's while controlling for plyometric time and weight training time.

Summary

This study has added to the body of research on how various training programs affect swim time performance in the freestyle sprints of high school swimmers. Larger improvements in swim time were found for swimmers who trained with a combination of swimming, plyometrics and weights. Recommendations are made to extend the scope of this study, and strategies are offered to increase the knowledge base of swim coaches, especially as it pertains to the impact of various forms of training on overall swim performance.

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APPENDIXES

APPENDIX A

Supplementary Tables for Chapter IV

Table A-1
ANOVA #1: Post 50 Yard Freestyle Time

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	17.97	2	8.98	.74	.480
Within Groups	1019.62	84	12.14		
Total	1037.59	86			

Table A-2
ANOVA #2: Gain in 50 Yard Freestyle Time Baseline to Post

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	20.74	2	10.37	2.17	.120
Within Groups	400.67	84	4.77		
Total	421.41	86			

Table A-3
ANOVA #3: Standardized 50 Yard Freestyle Swim Time

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	968.39	2	484.20	1.91	.155
Within Groups	21313.42	84	253.73		
Total	22281.82	86			

Table A-4
Estimated Marginal Means: Dependent Variable:
Post 50 Yard Freestyle Time

Training Program	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Swim Only	30.114[a]	.572	28.975	31.253
Swim Plus Dry Land	28.995[a]	.332	28.334	29.656
Swim, Dry Land and Weights	29.357[a]	.926	27.513	31.200

a. Covariates appearing in the model are evaluated at the following values: Gender = 1.44, Age = 14.97, Total Swim Yards = 199725.79, Years of competitive swimming experience = 3.97.

Table A-5
Estimated Means: Dependent Variable:
Gain in 50 Yard Freestyle Time Baseline to Post

Training Program	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Swim Only	1.87[a]	.347	1.17	2.56
Swim Plus Dry Land	1.27[a]	.202	.87	1.67
Swim, Dry Land and Weights	3.33[a]	.562	2.21	4.45

a. Covariates appearing in the model are evaluated at the following values: Gender = 1.44, Age = 14.97, Total Swim Yards = 199,726, Years of competitive swimming experience = 3.97.

Table A-6
Pairwise Comparisons: Dependent Variable: Gain in 50 Yard Freestyle Time Baseline to Post

(I) Training Program	(J) Training Program	Mean Difference (I – J)	Std. Error	Sig[a].
P1	P2	.60	.41	.144
	P3	-1.47*	.66	.028
P2	P1	-.60	.41	.144
	P3	-2.07*	.60	.001
P3	P1	1.47*	.66	.028
	P2	2.07*	.60	.001

a. Based on estimated marginal means.
* The mean difference is significant at the .05 level.

Table A-7
Training Program: Estimates:
Dependent Variable: Standardized 50 Yard Freestyle Swim Time

Training Program	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Swim Only	16.06[a]	3.23	9.63	22.49
Swim Plus Dry Land	16.87[a]	1.89	13.13	20.62
Swim, Dry Land and Weights	30.26[a]	5.21	19.89	40.63

a. Covariates appearing in the model are evaluated at the following values: Years of competitive swimming experience = 3.97, Total Swim Yards = 199,726.

Table A-8
Pairwise Comparisons: Dependent Variable: Standardized 50 Free Time

(I) Training Program	(J) Training Program	Mean Difference (I – J)	Std. Error	Sig.[a]
P1	P2	-.81	3.75	.829
	P3	-14.20*	6.13	.023
P2	P1	.81	3.75	.829
	P3	-13.38*	5.58	.019
P3	P1	14.20*	6.13	.023
	P2	13.38*	5.58 `	.019

* The mean difference is significant at the .05 level.
a. Adjustment for multiple comparisons. Least Significant Difference (equivalent to no adjustments). Based on estimated marginal means.

Table A-9
ANOVA #4:100 Yard Freestyle: Post Times

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	142.17	2	71.08	.79	.459
Within Groups	7596.19	84	90.43		
Total	7738.35	86			

Table A-10
ANOVA #5: 100 Yard Freestyle Gain Times

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	111.31	2	55.66	3.06	.052
Within Groups	1528.82	84	18.20		
Total	1640.13	86			

Table A-11
ANOVA #6: Standardized 100 Yard Freestyle Swim Time

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.14	2	.07	4.24	.018
Within Groups	1.34	84	.02		
Total	1.48	86			

Table A-12
Multiple Comparisons: Dunnett T3:
Dependent Variable: 100 Yard Freestyle Standardized Time

(I) Training Program	(J) Training Program	Mean Difference (I – J)	Std. Error	Sig[a].
P1	P2	-7.80*	2.50	.009
	P3	-13.67	7.26	.243
P2	P1	7.80*	2.50	.009
	P3	-5.87	7.21	.802
P3	P1	13.67	7.26	.243
	P2	5.87	7.21 `	.802

a. Based on estimated marginal means.
* The mean difference is significant at the .05 level.

Table A-13
Estimated Marginal Means: Dependent Variable:
Post 100 Yard Freestyle Time

Training Program	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Swim Only	69.86[a]	1.57	66.73	72.99
Swim Plus Dry Land	65.96[a]	.91	64.14	67.77
Swim, Dry Land and Weights	66.85[a]	2.55	61.78	71.91

a. Covariates appearing in the model are evaluated at the following values: Gender = 1.44, Age = 14.97, Total Swim Yards = 199,726, Years of competitive swimming experience = 3.97.

Table A-14
Estimated Marginal Means:
Dependent Variable: 100 Yard Freestyle Time Baseline to Post

Training Program	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Swim Only	3.35[a]	.77	1.81	4.89
Swim Plus Dry Land	2.81[a]	.45	1.92	3.70
Swim, Dry Land and Weights	7.11[a]	1.25	4.62	9.60

a. Covariates appearing in the model are evaluated at the following values: Gender = 1.44, Age = 14.97, Total Swim Yards = 199,726, Years of competitive swimming experience = 3.97.

Table A-15
Pairwise Comparisons: Dependent Variable:
100 Yard Freestyle Gain (Baseline to Post) Time

(I) Training Program	(J) Training Program	Mean Difference (I – J)	Std. Error	Sig[a].
P1	P2	.54	.90	.553
	P3	-3.76*	1.46	.012
P2	P1	-.54	.90	.553
	P3	-4.30*	1.34	.002
P3	P1	3.76*	1.46	.012
	P2	4.30*	1.34	.002

a. Based on estimated marginal means.
* The mean difference is significant at the .05 level.

Table A-16
Training Program: Estimates:
Dependent Variable: Standardized 100 Yard Freestyle Swim Time

Training Program	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Swim Only	10.48[a]	2.81	4.88	16.08
Swim Plus Dry Land	17.50[a]	1.64	14.24	20.76
Swim, Dry Land and Weights	25.07[a]	4.54	16.04	34.10

a. Covariates appearing in the model are evaluated at the following values:
Years of competitive swimming experience = 3.97, Total Swim Yds = 199,726.

Table A-17
Pairwise Comparisons: Dependent Variable: Standardized 100 Free Time

(I) Training Program	(J) Training Program	Mean Difference (I – J)	Std. Error	Sig[a].
P1	P2	-7.02*	3.27	.035
	P3	-14.59*	5.34	.008
P2	P1	7.02*	3.27	.035
	P3	-7.57	4.85	.123
P3	P1	14.59*	5.34	.008
	P2	7.57	4.85	.123

a. Based on estimated marginal means.
* The mean difference is significant at the .05 level.

Table A-18
Regression 1 Model[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	318.44	4	79.61	63.40	.000[b]
	Residual	102.97	82	1.26		
	Total	421.41	86			

a. Dependent Variable: Gain in 50 Yard Freestyle Time Baseline to Post
b. Predictors: (Constant), Total Swim Yards, Gender, Age, Baseline 50 Yard Freestyle Time

Table A-19
Variance Explained in 50 Yard Freestyle Gain Times

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.869[a]	.756	.744	1.12

a. Predictors: (Constant), Total Swim Yards, Gender, Age, Baseline 50 Yard Freestyle Time

Table A-20
Coefficients[a] in Regression 1

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	-15.631	2.084		-7.499	.000
Baseline Time	.390	.030	.883	12.928	.000
Gender	1.221	.250	.275	4.894	.000
Age	.231	.110	.123	2.096	.039
Total Swim Yards	-1.04×10^{-7}	.000	-.006	-.096	.924

a. Dependent Variable: Gain in 50 Yard Freestyle Time Baseline to Post

Table A-21
Regression 2 Model[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
2	Regression	1099.38	4	274.84	41.68	.000[b]

Table A-21 (continued)

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Residual	540.75	82	6.60		
	Total	1640.13	86			

a. Dependent Variable: 100 Yard Freestyle Time Baseline to Post
b. Predictors: (Constant), Total Swim Time (minutes), Gender, Age, Baseline 100 Yard Freestyle Time

Table A-22
Variance Explained in 100 Yard Freestyle Gain Times

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
2	.819[a]	.670	.654	2.57

a. Predictors: (Constant), Total Swim Time (minutes), Gender, Age, Baseline 100 Yard Freestyle Time

Table A-23
Coefficients[a] in Regression 2

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	-30.987	4.602		-6.733	.000
Baseline Time	.301	.027	.850	10.985	.000
Gender	1.995	.570	.228	3.502	.001
Age	.650	.251	.175	2.586	.011
Total Swim Time (minutes)	.000	.000	.065	.851	.397

a. Dependent Variable: Gain in 100 Yard Freestyle Time Baseline to Post

Table A-24
Regression 3 Model[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
3	Regression	527.26	4	131.81	21.18	.000[b]

Table A-24 (continued)

Model	Sum of Squares	Df	Mean Square	F	Sig.
Residual	510.33	82	6.22		
Total	1037.59	86			

a. Dependent Variable: Post 50 Yard Freestyle Time

b. Predictors: (Constant), Years of competitive swimming experience, Gender, Age, Total Swim Time (minutes)

Table A-25

Variance Explained in 50 Yard Freestyle Post Times

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
3	.713[a]	.508	.484	2.49

a. Predictors: (Constant), Years of competitive swimming, Gender, Age, Total Swim Time (minutes)

Table A-26

Coefficients[a] in Regression 3

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	46.268	3.458		13.380	.000
Gender	-2.015	.557	-.289	-3.617	.001
Age	-.532	.243	-.180	-2.195	.031
Total Swim Time (minutes)	.000	.000	-.340	-3.986	.000
Competitive Experience (years)	-.940	.233	-.344	-4.040	.000

a. Dependent Variable: Post 50 Yard Freestyle Time

Table A-27
Regression 4 Model[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
4	Regression	3862.04	4	965.51	20.42	.000[b]
	Residual	3876.31	82	47.27		
	Total	7738.35	86			

a. Dependent Variable: Post 100 Yard Freestyle Time
b. Predictors: (Constant), Years of competitive swimming experience, Gender, Age, Total Swim Time (minutes)

Table A-28
Variance Explained in 100 Yard Freestyle Post Times

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
4	.706[a]	.499	.475	6.88

a. Predictors: (Constant), Years of competitive swimming experience, Gender, Age, Total Swim Time (minutes)

Table A-29
Coefficients[a] *in Regression 4*

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	110.178	9.530		11.561	.000
Gender	-2.837	1.535	-.149	-1.848	.068
Age	-1.389	.668	-.172	-2.079	.041
Total Swim Time (minutes)	-.001	.000	-.360	-4.179	.000
Competitive Experience (years)	-2.890	.641	-.387	-4.508	.000

a. Dependent Variable: Post 100 Yard Freestyle Time

APPENDIX B

Institutional Review Board Document

Consent to Participate in a Research Study

Consent to Participate in a Research Study

Differences in Training Regimes and Time Trial Performances in High School Age Sprint Freestyle Swimmers

CHAPTER ONE: WHY AM I BEING ASKED TO PARTICIPATE IN THIS RESEARCH?

You are being invited to take part in a research study about different types of training regimes in high school swimmers. You are being invited to participate in this research study because you are currently swimming for your high school team this season. If you take part in this study, you will be one of about sixty people to do so.

CHAPTER TWO: WHO IS DOING THE STUDY?

The person in charge of this study is John A. Stratman at Eastern Kentucky University. He is being guided in this study by Dr. Charles Hausman [Advisor]. There may be other people on the research team assisting at different times during the study.

CHAPTER THREE: WHAT IS THE PURPOSE OF THE STUDY?

By doing this study, we hope to learn the effects of three different training regimes on timed swims made by competitive high school sprint freestyle swimmers of both sexes during a typical 5-month season.

CHAPTER FOUR: WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST?

The research procedures will be conducted at the high school team's normal practice site. You will need to come to practice regularly during the study. Each of those visits will take about 1 hour to 2 hours of normal practice time. The total amount of time you will be asked to volunteer for this study is your normal practice time over the next 13 weeks (Nov 1, 2012 to Feb 1, 2013).

CHAPTER FIVE: WHAT WILL I BE ASKED TO DO?

Swimmers from four different high school swim teams in Kentucky have been asked to participate in this study. Swimmers will practice with their teams in normal training conditions. On Nov 1st, each swimmer who has agreed to be in the study will participate in a 50 yard and 100 yard freestyle time trial. On February 1st, those same swimmers will participate in a 50 yard and 100 yard freestyle time trial.
Swimmers in the study will do a normal meet warm-up before swimming in the time trial study. Adequate rest and warm-down time of at least 15 minutes will be given between the two trials. Coaches make their normal coaching decisions when deciding if a swimmer is in particular groups.

Are there reasons why I should not take part in this study?
There are no particular reasons to not participate in the study.

What are the possible risks and discomforts?
To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life. You may, however, experience a previously unknown risk or side effect.

Will I benefit from taking part in this study?
You will not get any personal benefit from taking part in this study.

Do I have to take part in this study?
If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you choose not to volunteer. You can stop at any time during the study and still keep the benefits and rights you had before volunteering.

If I don't take part in this study, are there other choices?
If you do not want to be in the study, there are no other choices except to not take part in the study.

What will it cost me to participate?
There are no costs associated with taking part in this study.

Will I receive any payment or rewards for taking part in the study?
You will not receive any payment or reward for taking part in this study.

Who will see the information I give?
Your information will be combined with information from other people taking part in the study. When we write up the study to share it with other researchers, we will write about this combined information. You will not be identified in these written materials.

This study is anonymous. That means that no one, not even members of the research team, will know that the information you give came from you.

However, there are some circumstances in which we may have to show your information to other people. For example, the law may require us to show your information to a court. Also, we may be required to show information that identifies you to people who need to be sure we have done the research correctly; these would be people from such organizations as Eastern Kentucky University.

Can my taking part in the study end early?
If you decide to take part in the study, you still have the right to decide at any time that you no longer want to participate. You will not be treated differently if you decide to stop taking part in the study.

The individuals conducting the study may need to end your participation in the study. They may do this if you are not able to follow the directions they give you, if they find that your being in the study is more risk than benefit to you, or if the agency funding the study decides to stop the study early for a variety of scientific reasons.

What happens if I get hurt or sick during the study?
If you believe you are hurt or if you get sick because of something that is done during the study, you should call John A. Stratman at 859-358-6583 immediately. It is important for you to understand that Eastern Kentucky University will not pay for the cost of any care or treatment that might be necessary because you get hurt or sick while taking part in this study. That cost will be your responsibility. Also, Eastern Kentucky University will not pay for any wages you may lose if you are harmed by this study.

Usually, medical costs that result from research-related harm cannot be included as regular medical costs. Therefore, the costs related to your child's care and treatment because of something that is done during the study will be your responsibility. You should ask your insurer if you have any questions about your insurer's willingness to pay under these circumstances.

What if I have questions?
Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions about the study, you can contact the investigator, John A. Stratman at 859-358-6583. If you have any questions about your rights as a research volunteer, contact the staff in the Division of Sponsored Programs at Eastern Kentucky University at 859-622-3636. We will give you a copy of this consent form to take with you.

What else do I need to know?
You will be told if any new information is learned which may affect your condition or influence your willingness to continue taking part in this study.

I have thoroughly read this document, understand its contents, have been given an opportunity to have my questions answered, and agree to participate in this research project.

____

Signature of person agreeing to take part in the study   Date

____

Printed name of person taking part in the study

____

Name of person providing information to subject

APPENDIX C

Institutional Review Board Document

Parent/Guardian Permission Form

For Minor’s Participation in a Research Project

Parent/Guardian Permission Form

for Minor's Participation in a Research Project

Differences in Training Regimes and Time Trial Performances in High School Age Sprint Freestyle Swimmers

Why is my child being invited to take part in this research?

We would like to invite your child to take part in a research study about different types of training regimes in high school swimmers. We would like to invite your child to participate because he/she is currently swimming for the high school team this season. If your child takes part in this study, he or she will be one of about sixty children to do so.

Who is doing the study?

The person in charge of this study is John A. Stratman at Eastern Kentucky University. He is being guided in this study by Dr. Charles Hausman [Advisor]. There may be other people on the research team assisting at different times during the study.

What is the purpose of the study?

By doing this study, we hope to learn the effects of three different training regimes on timed swims made by competitive high school sprint freestyle swimmers of both sexes during a typical 5-month season.

Where is the study going to take place and how long will it last?

The research procedures will be conducted at the high school team's normal practice site. You will need to come to practice regularly during the study. Each of those visits will take about 1 hour to 2 hours of normal practice time. The total amount of time your child will be asked to volunteer for this study is their normal practice time over the next 13 weeks (Nov 1, 2012 to Feb 1, 2013).

What will my child be asked to do?

Swimmers from four different high school swim teams in Kentucky have been asked to participate in this study. Swimmers will practice with their teams in normal training conditions. On Nov 1st, each swimmer who has agreed to be in the study will participate in a 50 yard and 100 yard freestyle time trial. On February 1st, those same swimmers will participate in a 50 yard and 100 yard freestyle time trial.
Swimmers in the study will do a normal meet warm-up before swimming in the time trial study. Adequate rest and warm-down time of at least 15 minutes will be given between the two trials. Coaches make their normal coaching decisions when deciding if a swimmer is in particular groups.

Are there reasons why my child should not take part in this study?

There are no particular reasons to not participate in the study.

What are the possible risks and discomforts?

To the best of our knowledge, the things your child will be doing have no more risk of harm than you would experience in everyday life. You may, however, experience a previously unknown risk or side effect.

Will my child benefit from taking part in this study?

There is no guarantee that your child will get any benefit from taking part in this study.

Does my child have to take part in the study?

If you decide to allow your child to take part in the study, it should be because your child really wants to volunteer. Your child will not lose any rights he or she would normally have if you choose not to allow him or her to volunteer. If your child participates and either of you change your mind later, your child can stop at any time during the study and still keep the benefits and rights he or she had before volunteering.

If I don't want my child to take part in the study, are there other choices?

If you do not want your child to be in the study, there are no other choices except to not take part in the study.

What will it cost for my child to participate?

There are no costs associated with taking part in this study.

Will my child receive any payment or reward for taking part in the study?

Your child will not receive any payment or reward for taking part in this study.

Who will see the information my child gives?

Your child's information will be combined with information from other people taking part in the study. When we write up the study to share it with other researchers, we will write about this combined information. Your child will not be identified in these written materials.

This study is anonymous. That means that no one, not even members of the research team, will know that the information you give came from you.

However, there are some circumstances in which we may have to show your information to other people. For example, the law may require us to show your information to a court. Also, we may be required to show information that identifies you to people who need to be sure we have done the research correctly; these would be people from such organizations as Eastern Kentucky University.

Can my child's taking part in the study end early?

If your child decides to take part in the study, he or she still has the right to decide at any time that he or she no longer wants to participate. Your child will not be treated differently if he or she decides to stop taking part in the study.

The individuals conducting the study may need to end your child's participation in the study. They may do this if your child is not able to follow the directions they give him or her, if they find that your child's being in the study is more risk than benefit to him or her, or if the agency funding the study decides to stop the study early for a variety of scientific reasons.

What happens if my child gets hurt or sick during the study?

If you believe your child is hurt or if your child gets sick because of something that is done during the study, you should call John A. Stratman at 859-358-6583 immediately. It is important for you to understand that Eastern Kentucky University will not pay for the cost of any care or treatment that might be necessary because your child gets hurt or sick while taking part in this study. That cost will be your responsibility. Also, Eastern Kentucky University will not pay for any wages you may lose if you are harmed by this study.

Usually, medical costs that result from research-related harm cannot be included as regular medical costs. Therefore, the costs related to your child's care and treatment because of something that is done during the study will be your responsibility. You should ask your insurer if you have any questions about your insurer's willingness to pay under these circumstances.

What if I have questions?

Before you decide whether to accept this invitation for your child to take part in the study, please ask any questions that might come to mind now. Later, if you have questions about the study, you can contact the investigator, John A. Stratman at 859-358-6583. If you have any questions about your child's rights as a research volunteer, contact the staff in the Division of Sponsored Programs at Eastern Kentucky University at 859-622-3636. We will give you a copy of this consent form to take with you.

What else do I need to know?

You will be told if any new information is learned which may affect your child's condition or influence your willingness to continue allowing your child to take part in this study.

I have thoroughly read this document, understand its contents, have been given an opportunity to have my questions answered, and give permission for my child to participate in this research project if he/she chooses to participate.

Parent/Guardian's Name	Date	Child's Name	Date
Parent/Guardian's Signature	Date	Witness Signature	Date

APPENDIX D

Institutional Review Board Document

Assent Form for Minor’s Participation in a Research Project

Assent Form for Minor's Participation in a Research Project

(for minors between the ages of 13 and 17)

Differences in Training Programs and Time Trial Performances of Teenage Sprint Freestyle Swimmers

Why am I being asked to participate?
We are conducting research about different types of training programs used by teenage swimmers and would like to ask for your help because you are currently on a swim team.

What will I be asked to do?
If you decide to participate in this project, you will be asked to swim a 50 yard freestyle and 100 freestyle for time at the beginning of the season and another trial a week before the end of the season.

Do I have to participate?
Your parents know that we are asking you if you want to participate, but it is up to you to decide if you want to do this. You should not feel pressured to participate, and you have the right to choose not to participate. You will not lose any rights or benefits you would normally have if you choose not to participate. If you agree to participate now and decide later that you want to stop, all you have to is tell the researcher, and he will allow you to stop. You will still keep the rights and benefits you had before volunteering.

What will I get for participating?
You will not receive any payment or reward for taking part in this study.

Who will see the information I give?
Your information will be combined with information from other people taking part in the study. When we write up the study to share it with other researchers, we will write about this combined information. You will not be identified in these written materials.

This study is anonymous. That means that no one, not even members of the research team, will know that the information you give came from you.

Can my taking part in the study end early?
If you decide to take part in the study, you still have the right to decide at any time that you no longer want to participate. You will not be treated differently if you decide to stop taking part in the study.

The individual conducting the study may need to end your participation in the study. He may do this if you are not able to follow the directions they give you or if he finds that your being in the study is more risk than benefit to you.

Is there anything else I need to know?
To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life. You may, however, experience a previously unknown risk or side effect.

What if I have questions?
Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions about the study, you can contact the investigator, John A. Stratman, at 859-358-6583. If you have any questions about your rights as a research volunteer, you can contact the staff in the Division of Sponsored Programs at Eastern Kentucky University at 859-622-3636. We will give you a copy of this form to take with you.

I have thoroughly read this document, understand its contents, have been given an opportunity to have my questions answered, and have decided that I would like to participate in this study.

________________________________ ______________________________
Minor's Name Minor's Signature Date

John A. Stratman
Name of Individual Providing Information to Subject

APPENDIX E

Institutional Review Board Document

Script for Communicating Research Design to Potential Swimming Participants

<u>Script for Communicating Research Design to Potential Swimming Participants – John A. Stratman</u>

My name is John A. Stratman, a student in the Ed. D Educational Leadership program at Eastern Kentucky University. I am conducting research on different types of training regimes in high school aged sprint freestyle swimmers.

I have received permission from your Coach to administer a survey and collect data on a pre-season 50 freestyle and 100 freestyle time trial along with a post season time trial in the same events.

Your Coach will decide how he wants to train you, whether it is in the pool, dry land, stretching, and/or weight lifting.

I hope that you will participate in this study! If you don't wish to participate in the study, you will still receive the same coaching attention that everyone else on the team is receiving.

Thanks,

John A. Stratman

358-6583

Eastern Kentucky University

CURRICULUM VITA

JOHN A. STRATMAN

John_Stratman2@mymail.eku.edu

Home:
144 Tuscany Way
Richmond, KY 40475
(859) 358-6583

EDUCATION

2009 – Present	*Currently Enrolled*: Eastern Kentucky University: Richmond, Kentucky **Doctor of Education Degree** Educational Leadership and Policy Studies *Doctoral Candidate – All But Dissertation (ABD) Status*
2001 – 2002	Eastern Kentucky University: Richmond, Kentucky **Master of Science Degree** Physical Education *with a concentration in Sports Administration*
1995 – 2001	University of Georgia: Athens, Georgia **Bachelor of Science Degree** Health & Physical Education, K-12 Teaching

WORK EXPERIENCE

July 2013 – October 2013	Berea Community High School **Long Term Substitute Teacher, Health Education**
June 2007 - July 2013	Eastern Kentucky University College of Business and Technology Business and Technology Academic Advising Center **Academic Advisor**

Primary Duties:

- Academic Advisor for all College of Business and Technology students
- Recruiter for College of Business and Technology
- Instructor of Business orientation classes (3 sections per year)
- Coordinator of summer orientation advising and registration for CB&T.
- Judge for Mr. and Mrs. (FBLA) Future Business Leader of America

August 2005 – June 2007 — Eastern Kentucky University Athletic Academic Success Center
Athletic Academic Advisor & Acting Director

Primary Duties:

- Oversight of the daily activities within the SAAS Center.
- Supervision of three office staff: (1) Senior Office Associate, and (2) Graduate Assistants
- Facilitation of meetings with all Coaches as well as the delivery of briefings to Administrators in the Athletic Department
- Oversight of budget
- Monitored Academic progress and attendance of 350 student-athletes
- Evaluated all student-athletes eligibility
- Tutor Coordinator
- Provided academic advising services and assisted in class scheduling
- Participated in on-campus recruiting activities on weekends
- Prepared academic progress reports for all monitored, at-risk student-athletes
- Monitored study table sessions and computer labs
- Prepared applications on behalf of student-athletes for national academic award programs

August 2004 - August 2005 — Indiana University
Athletic Department Student Athlete Academic Center
Athletic Academic Advisor

Primary Duties:

- Advised student-athletes in all 22 Men's and Women's Sports
- Monitored academic progress and attendance of 130 assigned athletes
- Assisted Associate AD in maintaining relationships with campus student services
- Served as the advisor for assigned undeclared athletes
- Coordinated nominations of student-athletes for national academic awards
- Coordinated academic recognition banquets
- Evaluated student-athletes for summer school aid
- Assisted students requiring tutoring services and consulted with Learning Specialist on their behalf
- Provided academic services and assisted in class scheduling
- Participated in on-campus recruiting activities on weekends
- Prepared academic progress reports for all monitored, at-risk student-athletes
- Monitored study table sessions and computer labs
- Monitored student participation and progress in a Mentor Program

January 2003 – August 2004 — Eastern Kentucky University Athlete Academic Success Center
Athletic Academic Advisor

Primary Duties:

- Monitored academic progress and attendance of student-athletes
- Assisted in evaluating eligibility requirements
- Scheduled tutoring services
- Provided academic advising services and assisted in class scheduling
- Participated in on-campus recruiting activities on weekends
- Prepared academic progress reports for all monitored, at-risk student athletes
- Planned fall semester mentoring program

May 2002–
January 2003

University of Kentucky Athletic Department, C.A.T.S.
Center for Academic & Tutorial Services
Graduate Assistant – Athletic Academic Advising

Primary Duties:

- Monitored attendance and academic progress of all athletes for the following sports: Men's Basketball, Baseball, Women's Golf, Men's and Women's Swimming, Men's and Women's Track, and Men's and Women's Tennis
- Attended planning and academic major counseling sessions with athlete and counselor
- Assisted athletes in class scheduling and securing tutoring services
- Participated in on-campus recruiting activities on weekends
- Prepared weekly academic progress reports for monitored, at-risk student-athletes
- Monitored study table

August 2001–
May 2002

Eastern Kentucky University College of Health Sciences
Health Promotions & Administration Department
Graduate Assistant

Primary Duties:

- Substitute teaching of undergraduate Health classes

TEACHING EXPERIENCE

Eastern Kentucky University College of Business & Technology, University Programs and Berea Community Middle School & High School:

Fall 2013	MS/HS Health Education Classes
Fall 2003(2), Fall 2005(2)	GSO 100: Athletic Academic Orientation
Fall 2003(2), Spring 2004(2) Fall 2005 & Fall 2012	GSO 102: Transition to College

Fall 2007, Fall 2008, Fall 2009(2) Fall 2010(2), Fall 2011(2)	BTO 100: Business Orientation
Spring 2010, Spring 2011 Spring 2012	BTO 100: Business & Technology Orientation

Student Teaching

Jan 2001 - May 2001	**Jefferson High School, Jefferson City, GA** 9th grade Health Education & 9th – 12th grade Physical Education **South Jackson Elementary School, Jefferson County, GA** Elementary Physical Education

Practicum

Sep 1998 – Mar 1999	**Gaines Elementary School, Athens, GA** **Oconee County Elementary School, Watkinsville, GA**

PROFESSIONAL CONFERENCES

(NACADA) National Academic Advising Association
2007 Salt Lake City, UT

Region II (N4A) National Association for Athletic Advisors
2003 Vanderbilt University
2004 University of Tennessee

Region V (N4A) National Association for Athletic Advisors
2005 Penn State University

(N4A) National Convention
2003 St. Louis, MO
2004 Indianapolis, IN
2005 Raleigh, NC
2006 Pittsburgh, PA

PROFESSIONAL PRESENTATIONS

"Winning Ways" (June 2004). (N4A) National Association for Athletic Advisors National Convention. Indianapolis, IN. (Collaboration with Joan Hopkins, Senior Associate Athletics Director, University of Massachusetts)

PROFESSIONAL AFFILIATIONS

2010 – Present	(NISCA) National Interscholastic Swimming Coaches Association
2010 – Present	USA Swimming Organization
2010 – Present	Kentucky High School Athletic Association
2010 – Present	(NFHS) National Federation of State High School Associations
2007 – 2010	(NACADA) National Academic Advising Association
2003 – 2007	(N4A) National Association for Athletic Advisors
2003 – 2005	Ambassador Richmond, KY Chamber of Commerce

PROFESSIONAL DEVELOPMENT WORKSHOPS AND SEMINARS

March 2013	Strategies for Enhancing Student Management
March 2013	Going Retro: Teaching Techless
February 2013	Assessment Scoring Session
May 2012	(QEP) Quality Enhancement at EKU workshop Let the Data Drive
April 2012	(QEP) Quality Enhancement at EKU workshop Problem Based Learning
April 2012	(CSI) College Student Inventory Training Orientation and First Year Programs
June 2012	First Responder Workshop
April 2011	Noel Levitz Seminar
June 2009	Critical Thinking Workshop

PROFESSIONAL JOURNAL SUBSCRIPTIONS

2007 – 2012	The Chronicle of Higher Education

UNIVERSITY COMMITTEE MEMBER

2013	Orientation Process Mapping
2012 – Present	Graduation Task Force
2010 – Present	Degree Works User Group
2007 – Present	Orientation
2008 – 2012	University Undergraduate Advising
2012	Advisor Training Workgroup
2010 – 2011	Recruiting Department of Technology
2010	Commencement Speaker

SPECIALIZED TRAINING

Coaching Certifications:

Current	Adult CPR, AED Adult, Health & Safety Training for Swim Coaches, First Aid, and Fundamentals of Coaching

IRB Training:

September 2013	Human Subjects in Social and Behavioral Research (*Institutional Review Board Training)*

COACHING

July 2013 – Oct 2013	Berea Community Middle School Head Soccer Coach Berea, KY
Oct 2012 – Present	Berea Community High School Head Swimming Coach Berea, KY
Oct 2010 – Mar 2012	Model High School Head Swimming Coach Richmond, KY
May 2010 – May 2011	Colonel Aquatics Head Swimming Coach Richmond, KY

Summer 2001	University of Georgia Swim Camp – Assistant Swimming Coach Athens, GA
Oct 2000 – Mar 2001	Cedar Shoals High School Head Swimming Coach Athens, GA
Summer 1998	Athens Bulldog Swim Team – Assistant Swimming Coach Athens, GA

HONORS

High School Academics (Richmond Model)

- National Honor Society, 1994

Collegiate Academics (University of Georgia)

- Athletic Director's List

High School Swimming (Richmond Model)

- Ranked 2nd Nationally as 17-18 yr.-old in 50 Freestyle
- State Champion in 50 yd. and 100 yd. Freestyles
- State Record Holder in 50 yd. Freestyle

Collegiate Swimming (University of Georgia)

- 3 NCAA All-American, 14 NCAA Honorable Mention All-American Awards
- Key contributor to 3rd place team finish, 1997 NCAA Championships

National Swimming

- Semi-Finalist, 50m and 100m Freestyles, 2000 U.S. Olympic Trial
- FINA World Rankings: 50m Free (43rd t), 100m Free (68th t); 2000
- Junior National Champion, 50m Freestyle, 1994 Buffalo, NY

References, Transcripts, Course Materials, and Letters of Recommendation Available Upon Request